ALTITUDE AND HEALTH

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ALTITUDE AND HEALTH

BY

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PREFACE

By

SIR WILLIAM J. COLLINS, K.C.V.O., M.S., M.D., B.Sc. (Lond.), F.R.C.S. (Eng.), Chairman of the Chadwick Trust.

THIS *brochure* had its origin in a course of Chadwick Lectures delivered in London by Professor Roget in the year 1914. He was the first professor from a foreign country to be invited by the Chadwick Trustees to form one of their panel of lecturers. The conception and method of this course and of this booklet are thoroughly "Chadwickian." Professor Roget, like Chadwick, is no doctor, yet he has studied profoundly the fundamental principles of healthy living. The potency of *environment*, in the fullest and richest meaning of that term, is the theme of both the sanitary reformer of Victorian Britain and the Genevese professor who, in this *annus mirabilis* 1919, is as active as ever among his native Alps.

Since Professor Roget lectured in London aviation has passed from experiment to achievement, alike in the services of destructive warfare and of peaceful industrial intercourse. Its future can be imagined rather than described; hardly any bounds can be set to its beneficent and maleficent possibilities, nor any limit assigned to the direct and indirect results of its progressive development. All this serves to give additional stress and import to the study of the influence of altitude and its accompaniments upon the human organisation. Physiologists are busy with their observations on flying men, and Medical Research Committees are hatching reports, heavily charged with statistical data, on cardio-respiratory and bio-chemical results of rarefied atmosphere and reduced barometric pressure upon men of the Air Force. Although Professor Roget reports from *terra firma* and bases himself upon the solid fact of personal investigations, his results are not the less readable, nor do they lose in comparison as regards freshness and originality

by reason of the literary style with which he marshals his *data* and invests his conclusions.

Apart from mountaineering, plain-dwellers had aforetime but to ascend the Eiffel Tower, noting the concurrent barometric fall, or to descend in a diving bell, or enter the air-lock of a Greathead shield, submitting to the effects of condensation, to be led to speculate on the temporary and permanent results on so complex an organism as the human body of varying atmospheric pressure, with its concomitant phenomena. Mountaineers and balloonists vouchsafed much valuable, though often irreconcilable, information. Aviation has both intensified the quest and magnified the range. Professor Roget has addressed himself to a consideration of the relative potency of reduced pressure, rarefied air (with its lesser content of oxygen), moisture, and insolation (with its actinic and luminous qualities as well as its calorific, both radiant and aërial) in the effects of altitude on the human organism in health and disease. His correlation of the influences of altitude and latitude upon animal and vegetal life gives food for thought, while the vital statistics of the Augustinian monks on the Great St. Bernard and of the community of the Upper Valley of Avers afford suggestive testimony to the composite influences of altitude on diseases to which less exalted flesh is heir. A visit I paid to the charnel-house of the Great St. Bernard demonstrated to me how decomposition without putrefaction could proceed amid such environment.

The professor's attribution of a cold in the head (*coryza*), so unfortunately named, to "an ill-managed transition from physiological over-heat to the normal temperature" is felicitous, though such pathology may seem to pay insufficient homage to the bacillus. Epidemiologists, obsessed with the modern devotion to the omnipotence of bacterial causation of disease, will doubtless ascribe the immunity of mountain dwellers from zymotics solely to diminished opportunity for infection, but no one can read Professor Roget's pages without obtaining an assurance that the *soil* is a not less potent etiological factor than the *seed*, and that in the words of Dr. Farr, one of Sir Edwin Chadwick's friends and co-workers, "the vigour of their own lives is the best security men have against the invasion of their organisation by low

corpuscular forms of life. The primary object to aim at is placing a healthy stock of men in conditions of air, warmth, food, dwelling and work most favourable to their development. . . . Healthy sanitary conditions as to food, drink and cleanliness of person, house and city stand first in importance; after these, but subordinately, come quarantine, vaccination and other preventives as means of subduing mortality."

I commend Professor Roget's work on "Altitude and Health" as a worthy tribute to Chadwick's principles and doctrine and a valuable contribution to the Library which bears his honoured name.

AUTHOR'S FOREWORD

The author of this small book was requested, in the spring of 1914, by the Trustees of the Chadwick Trust, to give three public lectures on the subject "Altitude and Health." Those lectures were delivered in the Lecture Hall of the Royal Society of Medicine, 1, Wimpole Street, London, W., on the 6th, 13th and 20th of May, 1914. Sir William J. Collins, K.C.V.O., F.R.C.S., M.S., B.Sc., etc., Chairman of the Chadwick Trustees, presided over the first lecture. Sir Bertrand Dawson, K.C.V.O., M.D., etc., introduced the lecturer on the second occasion, and Sir James Crichton-Browne, M.D., F.R.S.E., Chadwick Trustee, on the third. The lecturer begs once more, and most heartily, those distinguished gentlemen to accept his thanks for so kindly lending him countenance in his appearance as first international lecturer for the Trust. He is painfully conscious that his modest effort hardly deserved such high patronage.

The manuscript was laid by during the long and anxious period of the War. It has now been brought up to date, but its inherent faults and shortcomings will be found only too apparent still. Though the author cannot help thinking of the publication of his book as perhaps opportune in the present circumstances, he can only dwell with sadness on that thought, because he has present to mind the woeful destruction of good health for the restoration of which altitude may now be looked upon as a real resource.

F. F. ROGET.

GENEVA,
June, 1919.

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PART I

CHAPTER I

The Alps the *sub-temperate* zone of Central Europe—Latitude *versus* Altitude—What is a mountaineer?—Steepness and the human frame—Cretinism.

Most people, when altitude and health are mentioned in their hearing, think at once of some extreme case of disease in which the mountain-air cure was resorted to as a forlorn hope. Or else their minds turn to thoughts of holiday making and mountain climbing.

Few actually think out the subject. Few realise that altitude determines the life conditions of hundreds of thousands of their fellow beings. Few care to know that air, sun, heat, light, cold, damp are objects deserving of study in themselves, as well as in their influence upon the pursuits, pleasures and health of man and beast.

The first thought of man in our European climates was to guard against cold. The further we go north, the colder; the higher we rise, the colder. Cold is, therefore, the principal unpleasant impression we gain from our climate.

But is cold injurious to health? The study of northern climes and that of high-lying table-lands, valleys and terraces will furnish us with the means of answering that most serious question.

Such places are inhabited, which certainly goes some way towards proving that they are healthy, but does not prove as much as one may suppose, since men do manage, and often prefer, to live under very unhealthy conditions. We shall, therefore, first study the effect of cold at high altitudes, both as a danger to health and as a means of keeping in good health.

We shall find that the Alps are the most extensive and most thickly populated "area of altitude" we possess in Europe. We shall describe this area in its physical characteristics as the *sub-temperate* zone of Central Europe.

In addition to the low average of temperature and along with the climatic conditions prevailing in the Alpine belt, we shall have to consider the effects of lowered barometric pressure, or thin air, and those accruing from particular conditions of dryness, moisture, light, heat and wind.

We shall show how, by rising above any given point, we improve our position in the matter of sunlight, and how we fail to share in an increment of its health-giving attributes when we are content to move about on the low levels of the globe—sunny seas excepted.

The law of reduced barometric pressure calls for close attention, because it means less air absorbed for every breath we draw.

How can scarcity of air be conducive to health ? When we have done with our study of cold, this will be the next point. Thin air does not only mean less air to breathe. It also means fewer impurities in the air, and so does snow.

Here comes in the question of the air *bacilli* which crowd the towns in which we dwell and infest our homes and our lungs.

Most of these germs may be removed by rising to an altitude. Yet mountain life is not in itself a guarantee of health.

The organic system of those who live at an altitude has to react against the thinner air and greater cold. To bring about this reaction purer air is not enough.

The strong health of mountain dwellers would be an unsolved mystery but for scientific research. This has shown that altitude brings about health-giving modifications in the composition of the blood, assisted by the wholesome diet mountaineers derive from the produce of their cattle in milk, cheese, and meat.

People moving from the Equator to either of the Poles progress from *latitude* to *latitude*. Owing to the shape of the earth, and taking into consideration the height and weight of the atmosphere, such progress is attended by a scientifically ascertainable increase in barometric pressure. We are not aware that the measurements of increase of air pressure and of the co-related increase in atmospheric density—both caused by the shortness of the globe's diameter from pole to pole, as compared with its length at the Equator—have yet been reduced

to reliable figures. The impending "standardising" of the barometric unit throughout the world—now that aviation opens the upper reaches of the air to exploration—will not be without influence upon this department of physics.

In the words of cosmography, our globe being an oblate body, its diameter from pole to pole is twenty-six miles less than it is at the Equator. At a guess, the sea level would be about thirteen miles nearer the centre of the earth at each pole than at the Equator. Hence a man rising by about ten miles above the sea level at the North Pole would not even reach the real equatorial sea level. This fact might lead on to interesting speculations as to the density of the air breathed within the Arctic and Antarctic circles. The effect of altitude upon human beings rising above a depressed level might there be studied, but he would be bold who asserted, because the Spitzbergen climatic range approximates that observed at the St. Bernard Hospice, that the conditions of climate on the highest Himalayan peaks would approximate the polar. Still, on the whole, the climatic scale that is perpendicular to the surface of the globe is comparable to the climatic degradation that culminates at the poles of cold, though we must allow, in the former case, for the greater value of sun effects, which are as favourable to life in the former instance as astronomic sun obliquity is unfavourable in the latter.

It is well known that the atmosphere rapidly diminishes in density as we recede from the surface of the earth. A diagram might be made exhibiting various strata of air resting upon the earth, the lower pushing out the upper and causing the interior mass to be more dense than the exterior strata. It is not known how high this elastic medium extends, but

> "to breathe
> The difficult air on the iced mountain's top"

is an experiment which shows the atmosphere to be exceedingly rare at no greater height than is reached by many of the superficial elevations of the earth.

The poet who wrote that line did not know perhaps that poor mortals may suffer from rarefied air without seeking it on iced mountain tops. Was he acquainted with "puna," or "soroche," the mountain sickness of South America?

Out of a variety of instances we recall to mind that of a

Scottish engineer who had to put together a steamboat for use on Lake Titicaca, in the Andes (3,824 metres). The boat could not be taken up whole ; its pieces had to be put together again on the height. As the native craftsmen did not understand the job, the engineer brought along with him Scotch and English workmen for that purpose. Those Europeans, used to the work on the coast line, took much more time than they would have required under ordinary conditions, the altitude being such an abrupt change. Nor did the engineer escape from atmospheric influences. He fell seriously ill and owed his life to the Catholic nun who nursed him in hospital, a beautiful woman whose charms made an ineffaceable impression upon him. The atmospheric effects were so enduring that even when, in London, months later, he gave a full verbal account of his stewardship before his board of directors, the aberrant disposition he had contracted on Lake Titicaca broke out unbidden and culminated in such a sudden and unbusinesslike inroad of the lady into his report that the hitherto unsuspected connection between mountain sickness and the pains of a loving heart was made abundantly clear to a convulsed audience.

To resume our topic seriously, people rising from a level become subject to *altitude*. The altitude limit of population is drawn at the point where people are no more found to form sedentary settlements. This limit, in Europe, is at present reached at an altitude of 7,000 feet, on the American continent at 13,000 (for instance, on the Potosi tableland, in Bolivia), in Asia at 16,000 (Thokschalung in Thibet). We use round figures. In Africa and in the Pacific it is not so high. South American railways actually rise to 16,000 feet (compare with the altitude of the top of Mont Blanc : 15,730 feet, or 4,810 metres).

This does not at all mean that settled communities of human beings could not live at higher altitudes. What we principally mean is that populations would find it troublesome to get their natural food, earn a livelihood, and keep in health at higher altitudes than they do now.

Communities following the recognised occupations of gregarious men that do live at extreme altitudes are either :

(*a*) Rural, viz., scattered and sparse; (*b*) Nomadic, viz., roving in a body from altitude to altitude or from place to place on an elevated table-land; (*c*) Urban, which needs no definition, as in the towns of Cuzco, in Peru (11,500 feet); La Paz, in Bolivia (12,000 feet); Potosi, mentioned above; Quito, in Ecuador (over 9,000 feet); Mexico (7,600), etc.

Such communities are acclimatised and individuals forming them are habituated. Their hearts are attuned. Their lives are normal under the conditions and the pendulum swings quite regularly with them.

It is generally assumed that when ascending to the higher regions of the earth we pass away into general winter conditions. If this be true, the change does not seem to be accompanied by the modification in racial characteristics which we might expect. But when we move towards the Poles, moving then towards life conditions which actually *are* wintry, combining as they do loss of light with cold, those conditions are accompanied by racial differentiation, which may also be noticed in the Himalayas, in those most God-forsaken parts in which the mountain climate is decidedly polar. In the absence of any known population near to the South Pole no such observation can be made in connection with the Antarctic, a probably uninhabitable mountain waste still unapproached by any but explorers.

So altitude does *not* determine racial characteristics, but latitude does. In that respect, an antarctic race would be interesting and might be analogous to the Thibetan, since the Thibetan climate seems to be more polar than altitudinal.

Yet, in the present aspect of the world, Arctic climate and altitude do have some features in common, though the absence of any conformity between polar and altitudinal races (should these exist) makes any ethnological comparison idle. But note that this reservation does not extend to the animal and vegetable world. In this sphere, altitude has preserved, or develops, polar characteristics. It is usual to look back to the glacial period for the link. This retrospect makes it fairly clear that analogy, when it is found to exist, is confined to the contrivance of *natural* means of resistance to cold. This on the whole rules out man, whose adaptation to cold is ruled by clothes.

There is between altitude and latitude a difference of which people are not necessarily conscious. It is the kind of difference of which the waiter makes us suddenly aware when he says: "Soup, sir; thick or clear?" We have seen that at an altitude the air is thinned between the ground we stand on and the stellar spaces. So the air which our lungs inhale, and in which our bodies are suspended, is light. To the influence and to some consequences of rarefaction the Arctic plain-dweller is not subject. He would rather be subject to the opposite phenomenon to a greater degree than in less extreme latitudes. But communities of mountain-dwellers and of plain-dwellers are alike conscious of cold. This consciousness may mislead them and induce them to disregard hygiene. In the case of both the first task of sanitary science would be the devising of the most sanitary means of defence against low temperature, whether by food, drink, housing or clothing.

It is quite possible, nay, very common, to live habitually at an altitude and yet be no mountaineer at all. A mountaineer is a person called upon by his occupation or pleasure to move habitually up and down more or less sharply inclined planes situated at an altitude. Men of different races and stations develop alike the mountaineer characteristics. Provided they start upon the process as children, and survive the acclimatising stage, they become mountaineers from the very first generation. It is now recognised that the removal of young children from the seaside to an Alpine resort and *vice-versa* is quite hygienic.

The Alps, Caucasus and Himalayas, on whose slopes are some very ancient seats of civilisation, present characteristics called *Alpine*, which, however, are not sufficiently marked to produce a common race. When we consider the Andes of Central and South America the case, though altitudinal, is somewhat different. Those ranges are neither Alpine nor Arctic where they are populous, and they are quite uninhabited at the enormous altitude where equatorial or sub-equatorial ranges are of a pronounced Alpine character.

In any case, the ethnology of mountain-dwelling communities does not concern a Chadwick lecturer. To him the races of mountain-dwellers are of no concern. His concern is about the physical, physiological and moral effects of mountain life

conditions upon the well-being of mountain-dwellers, whatever their races and of whatever mixture of race units the community consists.

A mountain-dweller may be called a mountaineer, we have said, only if he comes under the influence of altitude and *steepness* combined. Under the influence of altitude his organic life is carried on, while the conformation of his physical frame is amenable to certain effects caused by the extraordinary proportion which up hill and down hill walking bears in his case to ordinary progress on the flat. His physiological functions undergo some process of regulation determined by the particular kind of energy exacted from them, whether in the output of physical effort, or in the resistance demanded of them by the weather.

As aids to this regulating process we have to reckon the favourable auxiliary effects of altitude—atmospheric effects and natural gymnastics. These auxiliaries, however, in the case of the ordinary mountain-dweller, are much counteracted by his poor sense of sanitation.

Now, broadly speaking, an Alpine climate harbours both good and bad potentialities, because, on the one side, if it excites to out-of-door effort, on the other hand it lays severe conditions upon the exercise of the strenuous faculty. So let it be understood that we do not shun the obligation under which we are to own that the climate we call Alpine combines altitude—which is propitious—with Arctic or semi-Arctic weather, which is not propitious to the full development of man's sanitary instinct—at the best a pretty weak instinct in most, and a very modern impulse even in Christian Europe.

This definition may be put to very practical tests. For instance, it has not yet come to our knowledge that life insurance companies allow a rebate upon the premiums paid by mountaineers. The health privilege of an Alpine over a non-Alpine dweller is quoted at zero in the insurance market, while teetotalism is a commodity the value of which is marked in known figures.

Altitude has none the less a precise sanitary value, but one confined to individuals, and not available for mortality tables.

Within the range of our subject, the mountaineer's characteristics are individually gained. They are not generic

acquisitions. If they appear in a number of persons, it is by a mechanical process akin to that of drill or discipline. Sanitary habits spread by a kind of *moral* infection, by teaching, example and imitation, but the mountain-dweller, whether he become so by choice or be so as his inherited lot, acquiesces in the mountain habit pressed upon him by his environment. This habit is sometimes a good acquisition, often a bad one, almost always an unreasoning acquiescence.

There is, in the first place, his physical adaptation to environment. This might be styled the influence of steepness upon the human frame.

Feet.—When walking or running, the mountaineer's feet have habitually to deal with three positions which are not the most frequent with the born lowlander : (*a*) the up hill position, when the heel is planted upon the ground lower down than the ball of the foot ; (*b*) the down hill position, when the ball of the foot is lower down than the heel ; (*c*) the lateral position, when the foot is edged against the hill side. All three positions put upon the ankle joint a strain which is unusual with lowlanders. Observers will notice that, when in the first position, the born mountaineer lays his *whole* foot upon the ground, that he does the same in the second position, and that in the third, his foot does not rest on its upper edge only, but adheres to the ground on *both* sides. This means much more play of the ankle joint than the lowlander possesses.

The whole secret of the mountaineer's surefootedness turns on the great freedom which he gets by this adaptation to steepness. One unaccustomed to steepnesses and declivities, when going up hill, allows, as it were, his heel to swing loosely in the air and brings his weight to bear on his toe joints principally. This is wrong. The heel too should be used as a support. The same personage, running down hill, will stick his heel into the ground and shake his spine at each step. This is wrong. With the mountaineer, the ball of the foot reaches the ground as soon as the heel and, by pliancy, both breaks the shock and gives a sure hold by bringing the whole of the foot to adhere to the ground. When crossing a steeply inclined plane, the lowlander finds it extremely difficult to adhere to the ground by laying upon it the whole under-surface of his

foot, while the born mountaineer will do so without either pain or wrench.

Knees.—The effect of steepness upon the gait of the mountaineer is to develop the muscles which control the bending power of his knees. When he goes up hill, the knees are bent forward to receive the weight of the body. When he goes down hill, they bend for the sake of elasticity in checking the forward fall of the trunk upon its natural supports. The movement is emphasised both ways when the mountaineer carries a load, which he is called upon to do in almost all his out-of-door occupations. While the ankle does not show any anatomical variation externally distinguishable, the *gait* of the mountaineer is quite apparent. Even the least practised eye will distinguish at once, on parade, a company of mountain infantry —recruited in Canton Valais, for instance—by the forward bend of the knee, which gives them a most ungainly appearance on the flat.

Hips.—These show, from the same cause, a corresponding displacement. The mountaineer sits on his hips, as it were, when walking. The knees being bent forward at an angle, the hips and the trunk form a corresponding angle, to which the muscles get habituated, this being the position in up hill and down hill motion.

Chest.—In up hill motion the trunk and chest are naturally bent forward so as to be brought above the knees, for the sake of balance, particularly when the shoulders bear a heavy weight. This weight will rest on the hips and pull the shoulders back, with the result that the neck is craned and extended forward. Such is the picture presented by one who is a mountaineer by heredity. You should see him on a sharp incline, moving freely upwards with a heavy weight on his back where the declivity presents no path. His stature will appear broken up in zig-zag lines, moving with great elasticity at varying angles. The aim of the whole thing is balance and sureness. In down hill motion the trunk and chest, on the contrary, seem to linger behind the crural elongations. The stride will be very long, while the lowlander timidly shortens his stride in proportion as the declivity gets steeper. Such moderate hills as the Scottish Highlands breed a characteristic race of highlanders, but these do not share in the characteristics

of the Alpine peasantry, partly because there is no analogy of occupation, but principally because the gradients over which the Scotch Highlander is called upon to move are insignificant. They are not mountaineers.

Eyes.—The eyesight is extremely keen, though ophthalmia is not a rare complaint owing to the brilliancy of the snows, exposure to cold, sharp winds, and principally owing to the dislike of cold water, which characterises the peasantry everywhere.

Mountaineers have a remarkably steady "nerve." This, with their excellent eyesight, and power to distinguish dull moving objects at an enormous distance, makes them excellent shots.

They are generally remarkably intelligent, however much the condition of mind and body, which we call cretinism, may affect individuals of either sex in some village communities. There is nothing particularly Alpine in idiocy, but there may be in cretinism. Its frequent association with *goitre* and the striking physical malformation of the "crétin" make him an extremely unpleasant object to behold. The cause of cretinism has long been misunderstood. It has nothing to do with either water or air in the sense of the explanations hitherto attempted. But it is closely associated with the pastoral life of the mountaineer. The Alpine population is above all a population of cowherds, who, at one time, thought little of reducing to a minimum the labour required to fell trees and prepare firewood for the long and close winter. Families used to huddle in with the cattle in the byres, bartons, stables and sheds, on beds of hay or straw laid beside the dung of beasts, and within reach of the heavy breath of their nostrils. The effect of this airless, steamy heat upon the human beings bathed in it I might leave to imagination to guess, if cretinism were not there to witness unmistakably to the consequences. Picture to yourselves pregnant mothers confined in that atmosphere! Just think to what risks the babies were exposed when they drew first breath in that thick air and were condemned frequently to be left there for months till spring released them from captivity! Those filthy habits fortunately are speedily vanishing and cretinism is fast becoming an inconsiderable

quantity in the health statistics of the Alpine peasantry. Yet this baneful past still weighs heavily upon the population.

It does not come within our province to expatiate medically upon cretinism. It is a condition of ill health in which the glands of the system—principally the thyroid—are quite unable to fulfil their proper functions. Nothing is perhaps more hereditary, when once acquired, than slackness in the activity of the glands. Cretinism is prevalent in some districts more than in others, such as shut in valleys, hollows or sites, where stagnant water, stagnant air, and impermeable soils permit of the cumulative and intensive effects of confined oxidating processes with injurious gaseous resultants. Where could more noxious processes—consequent on respiratory and cutaneous excretion and organic decomposition—be found than amid the dreadful circumstances described above ?

There is an Alpine anthropological type which bears some of the outer aspects of cretinism without being a degenerate type. It may be a survival of an ancient race, presenting belated copies of a primeval pattern. Though intelligent aboriginal mountaineers, they are not the kind of men one of whom I would choose to go

> "And meet him, were I tied to run a-foot
> Even to the frozen ridges of the Alps,
> Or any other ground inhabitable
> Where ever Englishman durst set his foot,"

as Shakespeare put it when Alpine travel was still legendary.

CHAPTER II

The prejudice against cold as an alleged cause of phthisis—The geographical distribution of phthisis—The question of climatic immunity from phthisis—The helpfulness of moderate cold, irrespective of disease—The bad effects of excessive cold—Thermic, electric, hygrometric and barometric data viewed conjointly with cold—Pneumonia—The Alps as the European "area of altitude"—Australian and Swiss "tubercular" statistics.

Let us now locate more precisely our point of view. A scientific stickler would say that our subject is contained within a department in "physiotherapy," of which there are two sections: Thalassotherapy (the pursuit of health on the seaside), and ypsiatry (the restoration of health on the heights). But we simply mean a natural treatment by physical agents: light, electricity, air, water, climate, exercise, all at an altitude.

In this respect, recourse to altitude *does* fall within the province of hygienic relief by a return to nature. Our specialist would dwell upon the value of the open-air hardening process in promoting health. He would discuss the airing and cooling of the surface of the body, winter exposure to cold, the heating of the inner vessels, organs and coatings by exposure of the skin to the sun, so as to regulate organic combustion and foster chemical exchanges in the tissues. He would point out that sun, air, water, and the fundamental foodstuffs available for mankind have undergone no change since the ancient times when Hippocrates wrote his treatise on diet. He would further enlighten us on the employment of warmth and cold by artificial means; on muscular mechanics and on the refining of foodstuffs drawn from natural products, thus giving to the physiotherapy of the present day a complexity of range in which altitude has come to play no unimportant part. And, in so doing, he would do right.

Formerly, even cultured people had an unconquerable prejudice against cold. They looked upon it as the common cause of any and every lung disease. It seemed to them that mountain-dwellers were appointed by nature to be affected by

every kind of chest complaint, and that no wise dweller in the plain would ever repair to the heights to gain health. But the time came when, a distinction being made between lung affections, certain countries gained credit as being free from phthisis. Some countries were held to be quite free owing to a favourable latitude, and others owing to a favourable altitude.

There *are* a certain number of countries which seemed not to be infected with phthisis, but as these happened to be among the cold countries on the globe, that fact went against the opinion of the public on the causes of chest diseases. We now know that cold paralyses the microbe of the tubercle, about the very existence of which ignorance used to prevail.

1. Into the category of countries held to be *naturally* immune fell: Iceland, which would seem able to cure even those of its inhabitants who bring phthisis home from abroad; the Faroe Islands; that part of Eastern Russia which is inhabited by the Kirghiz; the icy coasts of Norway, Sweden, Finland and Siberia, on which nomadic Laps and Samoyedes are periodically on the move, and those immense polar tracts which are travelled over only by a few scattered Esquimaux.

One finds in almost all parts of the globe some points, belts, or zones of natural immunity represented by high mountains. This is "altitudinal" immunity, as compared with "latitudinal." As mean temperature goes down in proportion as altitude increases, this geographical fact, namely, the comparative immunity of mountainous regions, connected with the immunity of the northern parts of the world, proves that cold may actually be classed among the reagents against tuberculosis.

Thus latitude and altitude are somewhat confused sources of immunity, since there are mountain ranges even under the Equator, and the equatorial zone abuts to north and south upon regions which, though mostly low-lying and flat, are less hot, and so confer comparative immunity upon Europeans or others born under colder skies, who there seek relief from the tropical seed plots of disease.

2. Phthisis seemed comparatively *rare*:—

So far as Asia is concerned: in Arabia, Syria, Palestine, Persia, Siberia, Thibet, North China, Japan and Ceylon.

In Africa: in Madeira (oceanic climate), Morocco, Algeria, Egypt, Abyssinia, Central Africa (table-land), Congo-land, and the Cape.

In America: the highlands of Canada (Northern Canada), the table-land of Mexico, the Andes and their raised approaches and table-lands, from one end of the continent to the other, with the exception of towns.

In Europe: the northern and even the central parts of Scandinavia; Switzerland, which, though it is very much stricken in its flat and industrial regions, gives elsewhere a low figure of mortality from phthisis, for the very reason that it is so very mountainous; Corsica, Sardinia, the south and the north of Russia.

3. The countries in Europe in which phthisis was accounted moderately *prevalent* are the southern part of Scandinavia, Finland, the centre of Russia, Poland, Germany, Austria and Hungary, Rumania, Turkey, Greece, Italy, Spain, the Netherlands, Belgium and France. In France, it is of some importance to note that phthisis is more frequent in the north, with a decidedly "nasty" climate, than in the south, on the Mediterranean; and more frequent in the west, which is damp, than in the east, which shares in the drier and colder Central European climate conditions. Brittany has a dividing line running throughout its length. The half of the peninsula that is washed by the Channel is comparatively free; the southern, washed by the Atlantic, and wrapped in vapours throughout the winter, is a foster parent to the disease.

In America: the United States.

In Africa: the Canaries and the Madagascar table-land.

In Asia: Anatolia and the regions to the east of the Caspian Sea.

In the Pacific: Tasmania.

Lest we lay an undue stress upon this rough classification, it may be just as well to warn our readers that phthisis is a *demographic* affection. The shifting ratio of population has a great deal to do with it, and the habits of the people are often decisive. In that light, we may look upon a "young" country as offering ideally good conditions for the extirpation of the disease in comparison with Europe, where everything favoured the complaint in the past. The Commonwealth of Australia

is exactly the illustration we want, with its mild sea climate, freedom from rainy seasons, and almost entire absence of low damp-collecting mountain ranges, with its four million inhabitants of the same blood and habits, not intermixed with natives, and living on a fertile belt or on the coast line all round the dry interior waste. We are told that death from all tubercular diseases in the Australian Commonwealth were 0·92 per thousand in 1907. So the Commonwealth occupies—shall we say still, shall we say already ?—a very enviable position in regard to tubercular diseases, when compared with European countries. Whether the complaint will henceforth gain ground or loosen its hold depends entirely upon the will of the Australian people. At any rate, latitude does for them all it can.

The corresponding example—referring to altitude—must be taken from Switzerland. Switzerland is as uniformly Alpine as Australia is uniformly a maritime continent. It has a population almost equal in number to the Australian and of similar race. But the climate is rough, damp is prevalent, the people live in valleys instead of open plains. Well, for the Swiss, it is *altitude* that does all it can. The belt of lake and river fogs, hanging over the table-land in winter, from the slopes of the Jura to the foot of the Alps, and from the lake of Geneva to Lake Constance, marks in that country a vertical division (altitudinal) between immunity and liability. Above the upper rim of fog strata statistics show results as comforting as those which are collected on the lake and river level are ominous.

4. The countries in which phthisis is still very prevalent are : in Europe, the British Isles, where it is more frequent in England (overcrowding) than in Ireland ; more frequent in the north of Ireland (overcrowding) than in the non-industrial south. In Africa : Senegal. In Asia : India, China, Indo-China, and the Dutch Colonies. In America : Brazil, the Argentine, Chili.

We must here warn our readers that they may well take this enumeration and classification somewhat lightly. The contingent element of *prevention* is a very important factor which is gradually making classification inadequate. Statistics are uncertain, even if we confine ourselves to Europeans in their

usual places of abode, or transplanted to countries with a climate analogous to the European, such as British North America, the United States of America (to the exclusion of the negro, Chinese and Japanese population), and so on. Besides, there exists as yet no international standard in classifying, under one or several headings, deaths from complaints of a tubercular character.

With reservations, the notion that cold is a sanitary reagent may be accepted, on the condition that we understand thereby actually low temperature, such as is marked by degrees of frost, but when the cold is only moderate, that is, when a frosty temperature is only occasional during the winter months, the law of immunity by the instrumentality of cold suffers many exceptions, and may even be completely misleading.

This is the case in *mixed* countries when a mild climate in the south has for a counterpart in the north a "nasty" climate only, that is a climate in which it is only just cold enough in winter to generate unhealthy conditions. A severe cold may mean light and sunshine, and this is the condition of a sanitary cold, the ideal preventive of tuberculosis.

That is why the next law we have to lay down—the orographic law of altitude we can style it, to distinguish it from the purely geographical law of latitude—is so much more positive and reliable. The orographic law is not a law of complete immunity, as this can only be reached where pathogenic microbic life ceases entirely. But, then, the human body being itself a breeding ground for pathogenic germs, the ideal curative climate would necessarily coincide only with the extinction of human life altogether. In point of fact, there are but few exceptions to the general orographic law, to the effect that there is, all over the world, at varying heights, a belt of altitude within which freedom from tuberculosis can be attained by the application of purely natural hygienic or sanitary means, mostly operating spontaneously through climate, and partly brought to bear upon the patient by a voluntary application to his case of the principles and resources of sanitation and hygiene.

The deliberately accepted and systematically applied rules of healthful living emphasise the healing effects incident upon a good climate. We are on sure ground, in reading statistical tables, when we confine ourselves to the health-giving effects

of a good climate assisted by rules of hygiene, for we cannot expect to extract reliable figures from the observation of human beings whose lives have not come within the operation of such conditions. The mountainous valleys and recesses of the Atlas range, for instance, do not yield satisfactory statistics. Why? Simply because the inhabited parts are situated just high enough above the desert flatland to come within the zone of dangerous moisture, and not high enough to enter the zone of immunity through cold. But the folly of man may defeat the best climatic conditions. In the case of France, for instance, it would be ridiculous to blame the climate for the 300,000 deaths which occur there every year from tuberculosis.

What we have mostly to dwell upon in geographical and orographical indications is their significance as hints for the selection of a suitable dwelling place, subject to the fundamental doctrine of change. A mountaineer in bad health may make a better recovery on the seaside, but the opposite case will be numerically more striking because a far larger proportion of the inhabitants of Europe as borderers on the sea or flatlanders, and as dwellers at intermediate altitudes naturally go to seek health in the comparative freedom and airiness, increased intensity of light and completer isolation from human beings which they will find higher up.

So, whatever may be the degree of importance which may be attached to the geographical distribution of naturally unhealthy low-lying areas, sanitary considerations point to one and the same conclusion. If countries heavily stricken with disease owe this bad sociological characteristic to their climate, they should be abandoned in order to escape from the evil influence of their climate. If the evil influence arises rather from the contagion resulting from an accumulation of human beings, such places should be fled from all the more, since the risks accruing from contagion increase in proportion to the number of individuals infected with disease. If a removable microbe is at the bottom of it all—and such may be traced in any number even in the best of climates—the risk of developing it in one's system is proportionate to its frequency in one's environment. But it does not always follow that there is less probability of such contamination in a rural environment than

in a town, for in the healthiest of general conditions one's immediate environment may be very unhealthy.

The points we have made should now be presented in historical sequence as follows :—

The physical conditions of health have been a matter for consideration from the earliest times. At present they occupy a prominent place in the mind of the public and, of course, in the thought of the medical profession. But it is only in recent times that altitude, as a positively hygienic factor, has been distinguished from the generally condemned conditions of cold.

Formerly, cold was held to accelerate the progress of phthisis. It was even admitted that cold could alone bring about phthisis, on the vague assumption that people might be in some manner or other predisposed to that complaint. On the contrary, heat was considered as suited to guard against its outbreak and to delay its progress. Heat in confinement was preferred to heat out of doors. The belief is ancient and still well established that cold brings about those catarrhs designated "colds," and that these cannot but easily lead on to diseases which, for an ignorant public, are only an exaggerated form of contracted and neglected colds.

The notion of some constitutional vice in which tuberculosis was supposed to have originated came next, and dominated medical doctrine. Then cold ceased to be a sole determining active cause. The accepted formula came to be that cold gave its chance to this constitutional fault, brought it into activity, as it were, by the intervention of an external meteoric agent which induced in the mucous membrane a state of irritation. Later, when clinical observation was illuminated by contributions from pathological histology, it was allowed that, beside the operation of the constitutional fault in question, an *a frigore* inflammation of the lungs might pass into a caseous degeneration bearing the aspect of, and attended by some such fatal termination as, phthisis.

The discovery of the bacillus was by no means destructive of the notion of an inflammatory perturbation brought on by cold as a first step toward the disease, because the parasitic bacterion, when inoculated, always surrounds itself with an

inflammatory ring. When it has entered the lung, it develops there the more effectively the more the inflammatory process laid down to cold may have been complete and intense. But the *bacillus* in that case only strikes root in a ground well prepared to receive it. Meteoric cold often may induce physiological impoverishment of the organism, with the above result.

This brief historical survey, however far and rightly we may have got away from the primitive medical ideas on phthisis, imposes upon us a combat with the deep impression they have left on the public mind. The public must learn to bow to the teaching of geography. Have we not seen that the immune countries are precisely those which are coldest ? Do we not know that the countries in which the average shade temperature is very high have the effect of considerably accelerating the progress of the disease ? Do we not know that phthisis reaches its maximum of frequency in those regions of the temperate European zone which are only moderately cold, whether low-lying or no ?

Next came the time when 0° C., the thirty-two of the Fahrenheit, was recognised as a decisive criterion, because, as long as one did not overstep the geographical line between moderate cold and the pronounced frost in which safety lies, it was found, with respect to latitude, that the disease was as frequent in the north as in the south of a country astride on 0° C. in winter, and that in the vertical line, planes at a moderate altitude only were quite as injuriously damp as the critical planes 1,000 feet lower down.

These facts squared very well indeed with the existence of a microbe, when it was discovered. The microbe in question, like most beings of that sort, is paralysed by genuine cold. Under the tropics it develops most luxuriously and with great speed, while moderate warmth, whether climatic or artificial, prepares the feeding ground on which it thrives, though, no doubt, slowing down at the same time the speed of its evolution.

So much for cold as a *physical* health agent. This factor can properly and spontaneously exert its action in sub-temperate zones. This is how altitude comes in as a physical reagent upon health.

The *sociological* reagent upon health, in the sub-temperate

zones or altitudes as elsewhere, counteracts the favourable physical conditions. By aggregation, human beings *will* constitute seed-plots for the disease. The temptation to overcrowd is great in sub-temperate regions.

The now inveterate custom of using artificial heat, coupled with the gregarious habits of mankind, give to the predatory germ advantages which are by no means derived from the physical conditions underlying life. Cold does not visit life with disease. Its effect is to reduce and terminate human life when in excess of the power of resistance that the human organs can oppose to it. It reacts, when extreme, upon human life by inflicting upon it the same paralysing influences as it exerts on microbic organisms. It would be groundless to fear phthisis while exploring the circumpolar regions, or in ascending the peaks of the Alps in mid-winter. The risks to life and health under those conditions accrue from other sources than meteoric cold, in so far at least as the ordinary blood temperature can be maintained in spite of it. But winter quarters in sub-arctic regions or at altitudes are apt to combine the worst features of overcrowding and non-hygienic feeding. In our own mild latitudes, cold winter seasons, whether in the mountains or in the flatlands, have the same unfavourable effect as cold climates in this, that they favour overcrowding. The closer the association of human beings, the more frequent the outbreaks of disease. The greater probability of contagion in heated rooms would make isolation still more desirable in winter than in summer. But here arises a dilemma. Whether they be huddled together in artificially heated places by which microbic organisms will profit, or exposed to the outer air as a means of isolation in a meteoric environment unsuitable for microbic life, mortals run the risk of lowering their own vitality.

But the dilemma is only apparent. Sun and exercise will do all the good in the world to the human being who seeks hygienic isolation in the cold air out of doors. He need only protect himself from the inflammatory processes arising *a frigore*. This he may do by wearing clothes. We shall see later that this condition is not always indispensable. But, generally speaking, he cannot escape from it in civilised society, whether he seek the sunny Alps or the sunny South.

King Thermometer, with his blood-heat tide mark at 98·4° F., rules the situation. As the tide mark *must* be maintained, he may be obeyed at will, either according to the hygienic law, or against it. Leaving aside heredity and congenital predisposition or weakness, the manner of this obedience makes all the difference between good health and poor health. Medical men will uphold me in this statement. And in this connection I would remind my readers that it covers only as much medical ground as overlaps into hygiene and is contained within the four corners of sanitary science. The other term of our reference being altitude, the implication of cold is obvious. The non-infectious influence of high altitude is now generally granted, and, since the days of Dr. William Marcet, who opened the way, mountain stations have won the favour of the medical profession. This, of course, throws no discredit upon seaside stations. Each category has its own purposes to serve.

When the sanitary quality of mountains—if we may so express ourselves—became manifest, there was at first a tendency among experts to ascribe their beneficent influence to causes which were but distantly connected with altitude. It was thought that this influence, confined to the superior quality of mountain summer weather, was not put forth, or ceased to operate, under conditions of frost. But the *crux* in climatic temperature arises, as we have seen, at the temperature at which water turns to ice. This mean point of climatic temperature is found at altitudes which vary according to latitude and varies according to the season. Spring corresponds roughly to autumn, while winter and summer mark opposite extremes.

Roughly speaking, the plane of immunity thus determined is reached in the equatorial zone at a very high altitude above the sea level, while on the 70th degree of northern latitude the plane of immunity drops to the level of the sea. Some authors have attributed immunity to the reduction of atmospheric pressure irrespective of cold. For these, the plane of immunity passes midway between the sea level and the limit of everlasting snows. They would have it that the pressure is there so balanced that the expulsion of carbonic acid and the absorption of oxygen are accomplished in the proportions most

favourable to the prevention or palliation of phthisis. Some say that this reduction in atmospheric pressure increases the influx of blood to the lungs by accelerating the circulation of the blood in the pulmonary veins and arteries, and an amplification of the pulmonary vesicles would accompany this acceleration.

But the influence of lessened atmospheric pressure at an altitude cannot dispense, for efficacy, with the effects of cold upon microbic organisms, because, though high altitudes are not favourable to the development of such organisms, altitude cannot be considered as entirely free from them wherever organic life is existent, whether vegetable or animal. Atmospheric immunity is essentially a combined result, that of a low temperature with paucity of population. Everybody is aware of the marked discrepancy between barometric pressure, say, on the plane of immunity in Sweden, at an altitude of 1,500 feet, and that at the Equator, whether it be fixed at an altitude of 15,000 feet, which would be there the nether limit of everlasting snow, or at that of 7,500 feet only, which would halve the distance between the sea level and the permanent snow level. It is evidently the matter of common thermometric conditions that accounts for immunity rather than barometric data only.

On the other hand, there is probably, for each of us, a precise altitude which is, physiologically, the best for him. A thirty-five years' experience of summer and winter mountaineering has, with unfailing regularity, taught me that I am at my best —most playful and most light-hearted—at an altitude. As if by magic my corns disappear, any rheumatic pains vanish, gouty twinges pass away, any lumbago or sciatic neuralgia contracted at home lessens its hold perceptibly day by day. No sooner do I return to the level of civilisation than my feet drag, my corns call for the knife, all the symptoms reappear that bespeak an organism placed at a physiological disadvantage. I am a 6,000-feet man.

The continuous renewal of cold, fresh air is the dominant hygienic factor in producing robustness. There goes with the cold a general superiority of the northern races over the southern, in mental and physical energy, in moral steadfast-

ness, which is a commonplace in every geographical treatise and to which history bears emphatic witness. The Piedmontese, not the Sicilians, made the kingdom of Italy. The Prussians, not the Bavarians, made the German Empire. Political Russia has its heart in the north of geographical Russia. So it was with Spain when it defeated the Moors, with France when the kingdom's kernel grew from Paris to the Mediterranean. The American Civil War of Secession brought about the triumph of the north over the south, though it would hardly have been suspected that climate had had time to mark such a difference between men of practically the same race. There is no bringing into question the greater toughness of the Scotch and English north-countrymen when compared with the people of the south coast. To those examples taken from history many could be added from a recent past. It is a historical fact that northerners are, for energy, the superiors of southerners, while the same law holds good as to mountaineers *versus* lowlanders—at any rate in what concerns military superiority.

In spite of such overwhelming evidence, how many medical men still hesitate to impress upon the public the value of cold, fresh air, and how many among the general public oppose with all their might the reception of that impression! Every objection made on the score of the coldness of the atmosphere, or even of its dampness, in the lofty situations which are free from dust and miasma, should be met with a flat denial. Windows should be open day and night throughout the summer, and at night throughout the winter, however thick the snow may lie on the ground and however closely its flakes may be whirling through the air.

Public opinion attaches too much importance to cold in producing or increasing the severity of gout and rheumatism. In this respect also there is plenty of reforming to do. Medical geography does not by any means justify this prejudice of the public. Both affections are the result of imperfect internal processes which take place in mountaineer and flatlander alike. Attacks of gout are not more frequent in winter than in summer. In short, a cold climate is not particularly productive of those ailments, but, whenever they be produced, though there is no need to remove a patient from a cold climate,

sun-heat is none the less extremely conducive to the warding off of the acute stage when medical aid becomes useful.

The *meteoric* conditions which may be considered to be of real practical importance may be placed under four categories. There are *thermic*, *electric*, *barometric* and *hygrometric* conditions. The consideration of those points will bring this chapter to an end.

Thermic Conditions.—These interest us at this stage only with reference to the action of cold. We have seen how the general public was, till the most recent times, and is still to a great extent, persuaded that cold is the greatest enemy to health. In reality, there are hardly any ailments that may be entirely and exclusively attributed to meteoric conditions. These are mostly only adjutant causes. Yet it has to be admitted that an excess of cold—and this varies with each personal constitution—may bring about perturbations in the physiological economy of the human body which may conduce to pathological phenomena. There is a sliding scale in the action of the nervous system according to the degree of cold to which it is exposed. Some people are so sensitive on that score that they become fretful and irritable, particularly when it is the wind that conveys to their senses the impression of cold. They shiver easily, and react abruptly. But extreme cold, on the contrary, always induces a certain slowness in receiving nerve impressions and in the perceptive operations of the mind. Even people who are braced up by cold—a sure sign of healthful reaction—cannot endure it happily when it exceeds their own limit. Nervous conductibility is then impaired. Not only are sense-impressions and even mental representations less sharply defined and less keenly apprehended, but intellectual consciousness is dulled and the powers of moral discrimination are deadened. But if the cold is commensurate with the call which there is in all of us for a meteoric stimulus and tonic, the operations of the brain—we mean salutary inhibitions as well as decisions of will power—are thereby perhaps perfected. The understanding works with more certainty and as it were, more substantially. Will develops more energy. Maybe motion is not so rapid in following upon the determinations which provoke it. But it evinces more

regularity and puts forth more nervous power through the muscles. It is more exact and efficient. That is the superiority of mountaineers, whether they be born mountaineers or made such by training. Swiss guides, for instance, who are professionally exposed to cold, wind and weather all the year round, are remarkably well adjusted pieces of physiological mechanism : vigorous, quick, accurate. As a class they inspire such boundless confidence that we have often seen it placed in the wrong individuals.

But if cold becomes too intense, the delays in the manifestations of sensibility turn gradually to stupor. The general physiological numbness overtakes even the brain and, in the end, the progressive inertia communicated to the understanding and to the will arrests every function. A growing torpor invades the whole of the muscular system, paralysing for a time, or for ever, the reflex manifestations of the nervous centres.

As long as the temperature of the body can be maintained at its proper pitch, the circumambient meteoric cold is unobjectionable. It intensifies the breathing and chemical heating processes. The air is absorbed in a state of refrigeration which is eminently suited to the fulfilment of its function. The peripheric circulatory vessels, by their contraction, drive the blood back to the inner and essential organs of life and actuate them vigorously. The kidneys are called to greater activity, whence their owners benefit considerably. If the air is dry as well as cold, evaporation is enormous, particularly in the sun. The digestive organs work more smoothly. Digestion is much easier and there is a sharper edge to appetite. All this is the result of the increased flow of blood towards and in the organs of digestion, under the influence of the recoil of blood from the surface of the body. This, in the wonderful economy of nature, enables our organism to make up by increased alimentary combustion for the deficiency in the heat collected on the surface of the body. Diseases of the liver are less frequent in cold countries than in hot climates.

Those living at an altitude may experience from the sharpness of the cold neuralgic pain in such parts of the body as may be exposed to an icy wind or which are insufficiently protected when the sun does not shine. There may even occur cases of localised paralysis.

Now, with the effects of physical temperature we must associate consideration—which, in some respects, will lead us over the same ground again—of the temperature at which a healthy body does its *internal* work.

From the point of view of *bodily* temperature, animals fall into two large groups : The animals termed cold-blooded, whose temperature is variable, and hot-blooded animals, whose temperature is both high and *constant.* All invertebrate animals and, among vertebrates, fishes, batrachia and reptiles fall into the first class. Mammals and birds make up the second class, to which man naturally belongs.

Amid the variable conditions of temperature in their environment, warm-blooded animals retain a constant temperature, by the instrumentality of which the manifestations of life show great regularity, whatever the latitude or the season. The life of warm-blooded animals may be said to be autonomous in the sense that it is not affected by circumambient temperature, provided this temperature moves up and down without exceeding the limits within which the preservation of a constant temperature in the organism is, humanly speaking, possible. Within those limits and provided the stimulation which brings about contraction of our human muscles is alike in intensity, our muscles contract with the same rapidity whatever may be the surrounding temperature, and they do so to the same effect. This result is the consequence of constant bodily temperature, but it naturally ceases to obtain when any set of muscles, by being exposed to a low temperature, are no longer able to answer readily to stimulation. The heart of man moves in a constant rhythm as long as physiological or pathological causes do not intervene to upset that regularity, though the rhythm of the human heart cannot but be slowed down when its temperature sinks under the normal. The nerves of man exhibit a constant degree of conductibility, and when one observes variations in their excitability, the cause of this has to be sought in some phenomenon going on within the body or showing some connection with the circumambient temperature. This constancy in the action of the nerves is consequent upon constancy of bodily temperature. If the organism as a whole is refrigerated, nervous excitability is lessened and a point of refrigeration may be reached when it is annihilated altogether.

As we have seen, the moderate lowering of external temperature does not embarrass or delay the phenomena of digestion in man and in warm-blooded animals. The organs of digestion, stowed away in the depths of the body, are protected from thermometric changes ; they give forth gastric secretions equally plentiful and active whether the external air be frosty or rise to a temperature of 30° C. Not only does the refrigeration of the air bring about no refrigeration of the organism in warm-blooded animals, not only are chemical exchanges and combustions unaffected thereby, but, on the contrary, the effect of moderate meteoric cold is to increase them considerably, and in the proportion necessary for a supply of additional heat in such quantity as may secure for the organism its normal working temperature. So, practically, refrigeration brings about no injurious modification in the system of warm-blooded animals. Such a relation as this to meteoric cold shows our organism to be endowed with sufficient autonomous activity to employ vigorously the means at its disposal in a struggle against the influence which the lowered surrounding temperature could bring to bear upon its internal economy.

In order to uphold its temperature at the constant point our human organism has two processes at its disposal when the circumambient temperature goes down. It may either increase the quantity of heat which it produces, or it may reduce the quantity of heat which, in milder weather, it allows to radiate away from itself and be lost in the air. When the thermometer goes down, the quantity of oxygen consumed in the organism is larger, the quantity of carbonic acid that is produced is larger too, and both increase in proportion as the outer temperature is lowered. Under those conditions the inner combustions must and do increase, and they increase in proportion as the lowering of temperature is more marked. This is tantamount to saying that *under the influence of meteoric cold bodily heat increases in man.* Such a result evidently cannot be secured without an increased expenditure : a heavy draft is made upon the combustible supplies stored in the body. Depletion of those accumulated combustible reserves necessarily ensues. They have to be reconstituted by the absorption of a larger quantity of food, or by the selection of alimentary substances that are more nutritious. Else the organism

would run short of fuel and would be unable to make up for its heat expenditure, failing thus to keep up its temperature at the level of constancy.

A period of transition or adaptation, however short, exists always and is always perceptible. The first contact of the peripheric blood vessels in the skin with the cold air contracts them, and the blood circulation of the skin is reduced. The blood, thus driven back into the inner muscular tissues, flushes the viscera, and there it becomes available to a greater extent for the production of heat. As soon as a sufficient supply has been, as it were, manufactured in the inner centres appointed for that workmanship, the restored supplies of blood flow back through the peripheric vessels and flush them more fully even than they were before they came into contact with the lowered external temperature. Thus hyperæmia of the extremities follows upon discoloration. Dilatation of the blood vessels follows upon constriction. But, obviously, the whole process depends for successful and efficient working upon nutrition by previous accumulation of reserves in a measure sufficient to meet the emergency, followed, as soon as possible, by the ingestion of sufficient food from the outside to bring up again to their full complement the deplenished reserves, fat and glycogen.

It is well known with what facility, under conditions which fail to influence unfavourably men in good health, properly fed and rested, men worn out by toil or run down by illness turn cold. Those men have spent their reserves of nutrition in order to meet the calls made upon them by their work, or by the high temperature of fever. Before facing the ordeal of cold they have not been able to replenish their store of warmth for want of sufficient or proper food—the means wherewith to purchase it, the occasion to find it, has failed them—or else some disease has impaired their digestive powers. Such men are not in a position to stand the strain of severe cold.

Animals with constant bodily temperature, when they have begun to turn cold, still differ fundamentally from cold-blooded animals in this, that they use all means at their disposal in order to regain the high level of warmth which they have lost. Man must, at any price, keep at a higher temperature than the lowering circumambient temperature. While a cold-blooded

animal accepts the extreme refrigeration of the atmosphere in winter, man rebels. At first he becomes aware of the outer cold, he shivers, he is chilled, his teeth chatter. Then he falls within the embrace of the torpor which we have already described. His stupor is physical and mental. His movements are slower, his sensations are blunted, his faculties are drowsy. His breathing is narrowed down, his heart is numb. In the end death—a death that is gentle, for it comes without anguish and without pain—marks the end of this gradual dwindling away of all organic functions. Mammals generally perish when their inner temperature has gone down to 18° or 20° C. (from 64° to 68° F.). Man dies at between 20° and 24° C. (68° to 75° F.).

In this process of refrigeration biologists distinguish two phases. The first, in man, corresponds approximately with temperatures ranging from 37° to 32° C. (98·6° to 89·6° F.). The second corresponds to temperatures ranging from 32° to 20° C. (89·6° to 68° F.). Within the limits of the first phase the organism has sufficient recuperative powers within itself to re-establish its normal temperature, provided the cause of refrigeration is removed in time. Should by any mischance the second phase be reached, a human organism is no longer able to recover unaided the heat it has lost. The application of artificial heat is necessary—hot baths, hot linen, friction. When such aid is not available the organism grows colder and colder till death ensues by thermic deficiency though the body may have been moved out of reach of the cause which brought it to that low state of vitality.

There are, therefore, three periods: First, that of autonomous recovery; second, that of recovery with extraneous assistance; thirdly, that of death by organic cold brought on by an excess of meteoric cold.

But extreme *bodily heat* too is a feature at altitudes, where it is brought on by exposure to the sun or by excessive physical efforts. There is no doubt that the proportion of deaths from apoplexy is a striking item in Alpine statistics. We need, of course, not dwell upon the fatal termination of affections of the heart for which altitude may be responsible, because, in such cases, altitude is only the occasion of the termination and has nothing to do with its cause, since a heart

which has become worn out—or has contracted its fault—in an atmosphere of great density is naturally deficient in the elasticity required to adapt itself to the change in a normal way.

For all those reasons, ills which are not of a distinctly meteoric origin—extraneous—should not be ascribed to cold. The prophylactic condition to be fulfilled is that of keeping the bodily temperature at the proper uniform height. Over this it should not rise by overheating, nor sink by undue exposure. This happy uniformity may be obtained by clothing our limbs suitably, by avoiding over-exertion with consequent reaction, and also by getting the body to fulfil of its own accord the conditions which, by means of food and thanks to energy, will procure a regular output of warmth. Failure to comply with those elementary suggestions is the ordinary cause of the local or total disturbances in health which people would lay at the door of cold. It is pretty clearly made out by those, for instance, who have launched upon an astonished public the practice of winter and summer open-air school-life for ill-nourished, degenerate children, that bronchitis, pneumonia and pleurisy are not due to cold air. They are inflammations arising from a previously existing infection of the blood or tissues and are connected with damp.

None of the complaints we could add to those just mentioned, not even the most trivial cold in the head, may boast of an origin constantly and clearly meteoric. They are connected with physiological overheating and none are confined to distinctly cold regions or seasons. An ill-managed transition from physiological overheat to the normal temperature of the person affected is practically what people mean when they speak of having caught cold. They are not wrong, for they *feel* chilled, but cold under freezing point does not infect, and is even a natural disinfectant in the air. People who fight shy of low circumambient night temperatures in pure air do not know what they are sacrificing.

To those who have most battled with cold, its inconveniences are a source of humour, cast sometimes in a rather grim mood. In fairness to them, and also for some relaxation of mind in hearing the voice of an imaginative Frenchman, let us listen to what Dr. Jean B. Charcot has to say on the subject.

Dr. Charcot, who should not be confused with his father, the famous Dr. Jean Martin Charcot, of "hypnotic" fame, did a bit of polar circumnavigation in the South Seas, on the "Pourquoi Pas." He brought back from his sojourn in the polar regions certain impressions which may well be quoted here.

"Some people pretend," he says, "that they like the cold. *Un beau froid* is, with many sportsmen, a current phrase. But I expect that these are posers. I, who, to gratify my personal tastes, visited the magnificent solitudes of the ice-bound landscapes on the Antarctic continent ; I, a man who visits almost every year those countries in which the thermometer sinks to 30 or 40 degrees of frost, I acknowledge frankly that I harbour in my 'inwards' a holy hatred of cold. Out there, I learnt to look upon cold as an insidious, underhand and deadly enemy. Under 20 degrees of frost a most terrible fiend is let loose upon you : the chilblain fiend. Slily he creeps about and lays hold of you first by one ear, then by the other, then by a finger, then by a toe. Badly taken care of, or tended too late, the sores are sure to bring on gangrene and death to the limb afflicted.

"There is another terror : cold feet. In the intervals when rest from marching is imperative, when the circulation, which is our central heating apparatus, runs down, then cold bites one's feet, it eats into one's numb hands and brings endless trouble in its train. Come, sportsmen, my friends, please make me no longer the butt of your vanity by enlarging on the beauties of cold. You even say that, with time, one grows accustomed to low temperatures and that cold is then more easily endured. I pray you will allow that exactly the opposite happens. Who can honestly say that he has really become used to cold ? Explorers agree that its attacks are more easily repulsed in the first year than in those which follow. It would seem that the supply of heat which we bring away from warmer climes, well stored up in our bodies, runs out gradually. It is as though we were passing from a well-heated room into the street. We stand far better the cold of the outer air when we have been well warmed up than if we pass into it from a cold room. All that time can do for us is to provide us with a good deal of useful experience which we may use in fighting more effectively the most formidable enemy of mankind.

"Yet, I do not wish, after all, to unduly display, at the expense of sportsmen who have less to boast of, my heroism in facing those extreme latitudes. I must confess that I have instances to record when the extremely low temperature of the polar regions hit us far less severely than such ordinary weather-fare as two or three degrees of frost in Paris. I do not concede, for sure, that we grew accustomed to the cold, but we tolerated it because the absence of dampness came to the assistance of our patience. Dampness cannot be conjoined with severe cold. All lovers of winter sports will confirm my testimony on this point, that the thermometer indicates only the movements of the quicksilver column, while the reactions of our sensibility are far more complex. On some days, in the middle of Paris, I might be caught murmuring to myself, with the truest accent of sincerity: 'Begad, what a dreadful cold! How much nicer it would feel at the South Pole.'

"But, when I give vent in that way to an ill-considered optimism, I am not on the coasts of the Antarctic continent, and the memory of those days has grown blunt, when the wind began to blow, transforming the solitude more than ever into a howling wilderness. Imagination recoils from the thought of anything so dreadful. Filled with a blue terror, it flies from this dreadful vision of fellowship with cold and death. There is perhaps no better scientific definition of cold than this: the absence of life. Victor Hugo speaks of '*La mort aux froides mains.*' Why, indeed, should one's corpse be cold? Fellowship with cold and death lurks behind the queerly sublime impressions I experienced out there, on the border of a continent imperiously dominated by the spirit of death, a land in which all germs of life are for ever buried under an ever victorious ice-crust, a land in which alone human will may for a short time elude the touch of the relentless hand.

"To have experienced all the bitterness of cold is to realise in its surpassing beauty the meaning of the myth of Prometheus, that Prometheus who, because he snatched from the gods the secret of fire, was worshipped as one of the greatest heroes of humanity. Will it ever enter into any one's head to fall down in mute adoration at the feet of the trivial modern scientists who compelled cold to enter the service of man? Of course not.

However much their important discoveries have given rise to flourishing industries, they can never be so popular as the fire-snatcher. Please recall to mind the magnificent historical romance of J. H. Rosny, entitled '*La guerre du feu*,' the war for the recovery of fire, in which a self-sacrificing hero goes through untold hardships in order to restore to his tribe the flickering flame which it recklessly allowed to die out and for want of which it was doomed to perish.

"Hence, out of fire came civilisation. The primitive human hordes gathered round the hearth. By fire they overcame the terrors of night and the sterile gloom of winter. At the fireside they gained consciousness of themselves, and with this realisation of their common impending destiny their gods were born."

Dwellers in hot countries find relief from the evils attending an unusual measure of heat by moving temporarily to the heights, which exist almost everywhere within reach. This habit may take the form of periodic migrations, the causes of which are often partly economic as well as hygienic.

Electrical Conditions.—The electrical conditions of altitude are a chapter of the general effects of electricity applied to human physiology by the unaided operation of nature. We can with difficulty disjoin them from the general meteoric effects to which dwellers at an altitude are subject. That these are on the whole advantageous is a fact that has now gained general recognition.

Barometric Conditions.—Observations made in ascending mountains, and upon living organisms set to work in *cold* rarefied air, or simply stationed there, prove that humanity cannot endure without some risk sudden and considerable changes in atmospheric pressure, when adding the strain of work to that of low temperature. By these strains the physiological equilibrium is more or less disturbed, sometimes fatally in extreme cases. But this does not apply to people who dwell permanently at an altitude, provided they do not court an accident by rising suddenly and unpreparedly to a much colder altitude. The general conditions underlying the effects of modified barometric pressures in connection with low temperatures still require some scientific examination. We know, for

instance, that at the North Pole (which is on the sea level) we are by some twelve miles closer to the centre of the globe than on the sea level at the Equator. The radius of modified gravity, from the top of the Himalayas to the lowest cold point attainable on the surface of the earth, is therefore seen to be considerable, as compared to the range of our physiological faculties of adjustment. But our scientific data as to the density of cold air at the Poles are still under question, and we do not know whether the pathological occurrences noted by polar explorers are, strictly speaking, meteoric in their origin. The process of physiological exhaustion during a long sojourn at a very cold terrestrial altitude appears, at any rate, to outlast in its effects any merely barometric inconvenience of which one may become aware at such an altitude. As the Antarctic continent has a table-land rising to an altitude of 10,000 feet, and dominated by mountain tops of an additional 2,000 or 3,000 feet, it presents an interesting field for combined study of such phenomena as cold and altitude.

Hygrometric Conditions.—Damp acts both upon nutrition and calorification. It interferes with the cooling down of the body by checking evaporation. A dry atmosphere, on the contrary, increases in quantity, but shortens in time, the activity of the perspiratory process. At an altitude, in the sub-temperate zone, the hygrometric conditions are favourable to human health, because long periods of dryness alternate with short periods of comparative moisture. The absence of irritant dusts rids both dryness and moisture of the risks to health of which they may be vehicles elsewhere.

To sum up, meteoric agents are so extremely wide-spread geographically and, pathologically, so vague, that they are in our case of quite secondary importance. They have a part to play in almost every malady, but they are neither principal nor exclusive agents in the bringing about of any. This being the case, one may safely say that meteoric influences, so far as they may work for good or for bad, are in a sense so very platonic, or trivial, that the simplest rules of sanitation should suffice to meet the influence of cold or altitude upon morbidity.

That pneumonia occurs chiefly in the cold parts of the globe, and that its outbreaks in temperate or warm countries show a

majority of cases in hilly parts, where temperature goes down in proportion as altitude increases, is one of the few points requiring an explanation. This is afforded by more and more credit accruing to the modern proofs that pneumonia is of an infectious nature, which connects it with the domain of fevers, and is bred indoors. Be this as it may, statistics do seem to show that those who dwell permanently in damp cold countries show a higher proportion of cases of pneumonia in the comparative tables of disease. This observation applies to *moderate* altitudes as much as to extreme latitudes. Moderate altitude is almost always damp, as well as cold, with rare frost, a heavy rainfall, frequent sheets of water, and, as a distinct characteristic, fog in *winter*. We shall see later on that the remedy for this situation is a strengthening of the lungs, while hitherto a mistaken notion of hygiene has led to a further weakening of delicate lungs by coddling, even amid the very conditions which would be conducive to their invigoration.

Dysentery, when not caused by damp, may be the outcome of too rapid transitions from one temperature to another, or follow to some extent changes in barometric pressure. But such "barometric" dysentery is, at an altitude, little more than a process of physiological readjustment which, when under hygienic control, works rather for good than for evil. Dysentery arising from physiological exhaustion and forced exposure is a malady, and to this meteoric conditions contribute but a very slight auxiliary element.

In Europe the Alps are the principal as well as the typical centre of altitude. Political divisions on the map are of no account here. For the hygienist, as for the geographer, the Alps are an oblong mass of raised telluric matter extending from the Riviera and Genoa on the Mediterranean to Vienna in Austria and Trieste on the Adriatic ; from the lakes of Constance and Geneva (but at opposed extremities) to within twenty miles of Milan. Their mass springs from an altitude of 300 feet above the sea, passing to a base-line of 1,800 in other parts, and rising to the altitude of about 16,000 feet on the top of Mont Blanc (4,810 metres). They shelter about ten million inhabitants. The mean scientific temperature is inferior to that of the surrounding flatlands. Above the snow-line, which

curves about from the altitude of 8,000 to 9,000 feet, the mean temperature is under zero centigrade. It is perhaps, on the whole, undistinguishable from zero as low down as 6,800 feet, where the useful period of vegetation does not exceed three months. The highest permanently inhabited spot in the Alps, the great St. Bernard Hospice (a little above 8,000 feet), shows a mean temperature of one degree above zero (— 8·5° C. in winter, — 2·4 in spring, + 4·6 in summer, — 0·2 in autumn). The thermometer marks sometimes more than thirty degrees of frost. Taken all over, the mean shade temperature in the inhabited Alps is under + 6° C., two degrees less than the corresponding average on the plain of Bavaria, its nearest neighbour to the north. Southern exposures show markedly local figures, which give the lie to the Alpine average, an outrageously misleading formula with respect to either full north exposures or full south exposures viewed separately.

Where the Alps dip down to 300 feet above sea level the olive clothes their flanks. The vine ripens at the altitude of 4,000 feet, amid the Pennine Alps, in some favoured spots, and ripe mulberries may be gathered from magnificent trees in protected open air nooks at an altitude of 3,000 feet within a mile of the Aletsch Glacier. On the whole, the isothermic curves on each face of the Alps fall in with the hypsometric curves (curves of equal altitude).

To speak of winter temperatures : in January, the Bavarian average comes out at minus two, the Alpine at minus four, the Venetian at plus two, the Alpine average being typical of sub-temperate European climate. As a point of comparison with respect to heat, the July average is plus twenty-three at Botzen, plus eighteen at Innsbruck, plus fifteen in the Central Alps. The Alps receive more than three feet of rain as against two falling on the plains from which they rise. The St. Bernard Hospice, at the altitude of 2,470 metres, acknowledges seven metres of snow to one metre of rain. An infinite variety of hourly and local temperatures, of rainfalls, snowfalls and exposures, underlies these averages. Hence the character of vegetation is regulated by altitude and exposure combined. The latter, depending on planes most diversely inclined, whether as related to the cardinal points (faces), or as related to the perpendicular (steepness), and consisting of such varied

materials as ice, snow, rock and all varieties of soil, totally upsets any attempt at uniformity in the notation of temperature, except by wide sweeps of generalisation.

A just appreciation of those facts will show that the Alps are in Europe at once the most compact, the most diversified in climate (by the capricious play of latitude and altitude), the most thickly inhabited and the most central field of observation and experiment for scientists inquiring into the reaction of altitude upon health.

In this respect, it would be interesting to compare the tubercular statistics of the most favourable latitudinal climate with the Swiss sub-Alpine and Alpine zone, under fairly equal conditions of numbers and race. We have already mentioned Australia. Unfortunately, the statistics issued by the Commonwealth of Australia, which we have before us for the years 1905, 1906, 1907, and which it would be proper to compare with the corresponding Swiss statistics, are vitiated by the enormous proportion of so-called unspecified, ill-defined, or "other" diseases (10,000 out of 45,000 recorded deaths in 1907). The Swiss statistics spreading over the same years give 6,000 deaths from pulmonary phthisis in 1907, 2,800 from other tubercular diseases, 5,000 from the acute chest complaints proper, against a total of a little less than 3,000 deaths from non-medically attested cases and cases of uncertain diagnosis. The statistical centres which may be described as more particularly Alpine within Switzerland (zone of population extending from 3,000 up to 6,000 feet), are the Bernese Oberland, the cantons of Uri, Schwyz, Unterwald, Glarus, Grisons, Valais, and the upper reaches of Ticino. In most of these, the actual statistics are vitiated, as health statistics, partly by the low-lying and damp districts forming the bed of the valley, partly by immigration of tubercular cases, partly by the wretched hygiene of the inhabitants, which seems to become worse in proportion as the climate conditions are improved by altitude. The local climate of Sierre, for instance, is the driest in Switzerland and, probably, the soundest in the whole of Europe, sunny and frosty to an extent which nobody could expect or would realise till personally experienced. Under those exceptionally favourable circumstances the statistical district in question shows 18 deaths from pulmonary phthisis, 12 from other tubercular

diseases, 26 from pneumonia, and quite an abnormal proportion of cases of non-medically attested deaths (79), all in 1909, a year that is striking in no particular.

Such statistics, like the Australian, are quite unusable. They show that the difficulties in the way of medical attestation are still far from being overcome, that too many people are quite indifferent to the most elementary principles of hygiene. In the Sierre district, for instance, they throw away the chances that are given them by their range of inhabitation, which extends from the highest grazings at an altitude of over 6,000 feet down to the most magnificent vineyard country, with winter sun, lasting twenty-five days in December, 1913, and twenty-two days in January, 1914 (last pre-war years).

Such is the powerlessness of the best local circumstances, in the absence of any observation of the laws of health by the native dweller. If we turn to the careful "sanitary" immigrant, it is quite another story. We find in the Alps ladies and gentlemen in rude health who cannot spend more than two months in the English climate without a recurrence of their chest and throat complaints. In the region facing south above Sierre quite a colony of perfectly healthy, happy, hard-working settlers has congregated, composed of men and women who had previously spent from two to three years in sanatoria. The contrast between the native and adventitious categories of dwellers is most instructive.

CHAPTER III

The barometer, oxygen and ozone—Aerial germs and dusts—Immunity therefrom—Complexity of mountain climate—Barometric pressures—Temperature—The Alpine winter—Luminousness, calorific and chemical radiations—Summing up—From climatology to hæmatology.

As one ascends a mountain the glass "goes down" by a *less* amount at every stage of progress, and in proportion to one's vertical displacement, because the density of the air grows less and less as one rises in the atmosphere. Any one will realise this on glancing at the altitude marks or grooves which form a scale around the face of his aneroid barometer. They are closer and closer in proportion to the height marked. At a pressure equal to half an atmosphere any given quantity of air weighs exactly half what it weighs at the pressure of one atmosphere. To express this in the decimal system, one litre of *air* will then weigh in grams the half of 1·293. This, because the molecules are less and less closely packed the further they are from the centre of the earth. At an altitude of 25,000 feet an ordinary glass would fail to record atmospheric pressure, the density being then no longer susceptible of accurate expression by physical instruments.

The proportion of oxygen to the other gaseous components contained in atmospheric air, that is the percentage of oxygen, remains apparently the same at all measurable heights, viz., 21 per cent., so that, when the litre of air weighs 1·293, divided by 2, the weight of oxygen that can be got out of a litre of air is reduced by one-half. Now, in any given cubic mass of air oxygen is practically the only active agent we are concerned with. Why? Because "no phenomena of life—animal, vegetable, terrestrial, marine or aerial, none of the processes of combustion, oxidation, respiration, nutrition, growth, fertilisation, reproduction, decomposition, putrefaction, or fermentation; hardly any organic or inorganic chemical change or interaction can begin or continue without the presence and

assistance of oxygen, direct or indirect. Free, and in the combined state, oxygen forms no less than 65 per cent. of the total weight of the human body. It forms one-fifth of the volume of the atmosphere, by weight eight-ninths of water, and nearly one-half by weight of the whole crust of the earth, on and in which living organisms have their entire existence. It is constantly being taken in and given out by every form of living organism—animal and vegetable."

There is much *ozone* at altitudes. When exposed to it, paper impregnated with iodide of potassium and starch turns to the deepest blue. The proportion seems to be from nine to ten parts of ozone at an altitude of 12,000 feet, and from two to three parts at Paris. The hygienic properties of ozone are now too fully recognised to need dwelling upon here. Its high percentage is one of the most noteworthy sources of health on the high terraces of the Alps.

Germs.—The air contains *germs* as well as inorganic dusts. The former may ferment, in fact do ferment, and become toxic, that is, they generate the poisons which, in medicine, go under the name of infection. They pass into the human body by mechanical contagion, or else they are generated there.

Here we have only to consider the aerial microbes or bacteria. Roughly speaking, to one bacterion per cubic metre on the Atlantic correspond 200 if we examine the air immediately above the streets of Paris, growing to 80,000 in the worst pathogenic centres of that city. There is no proof, however, that if such dusts are artificially injected into the human body, in an infusion, for instance, they will produce a disease to order. The natural process of infection is of another character.

Now, if we examine circumambient air, first in open highlands, then in open flatlands, and then in a large town, we shall practically find that there are no bacteria at an altitude of 6,000 feet or any higher attainable altitude; a computable few, say, in the *middle* of Lake Thun, in Switzerland, just within the ring of hygienic altitude (1,800 feet and no habitations); three times more in any given *hotel* even if at a tolerably high altitude (3,000 feet above the sea); twelve times again as many in a given open flatland, and eight times again as many, say, in the fashionable quarters of Paris.

But we trust that those among our readers who are sensible will not take those alarming figures too literally. It is true that bacteria are carried by the air. In some instances they may float freely in it, or they may be attached to particles of dust, or they may be carried by flying insects. But there are reasons for believing that the danger of infection through germs floating freely in the air, or attached to particles of dust, is by no means so frequent as it has been represented, though living organisms can always be found in the air of almost every inhabited place. The place where there is danger of infection is in the immediate neighbourhood of a person suffering from the disease—if that disease is one which affects the air passages, the mouth, throat or lungs, as in the case of tuberculosis, or even of catarrhal colds. Such a person distributes *fresh* microbes, strong and vigorous, and therefore dangerous. Apart from these sources, there appears to be little danger of contracting an infectious disease from germs that float in the air. It is much greater in what concerns germs carried by insects from one seat of infection to a seat of life liable to infection. With reference then to altitude, as high as insects that visit the habitation of man can elevate themselves, or are bred, so high the danger subsists. In order to deny it, it would be necessary to prove that, as altitude increases, not only does the environment of living beings become more and more sterile, but that something happens that is much more important: namely, that the processes of life, fermentation, decomposition, etc., should themselves become aseptic by spontaneous sterilisation.

The gradual rarefaction of microbic life ambient in the air, as we proceed higher, say, along the slopes of the Alpine ranges, seems to be the outcome of several causes. We may mention again the diminution of barometric pressure, since any given volume of flatland air, transported to an elevation of 12,000 feet, will not only bulk once again as much in space, but also disperse its dusts to an uncontrollable extent. Second, the atmosphere getting more and more rarefied, loss of density makes it more and more unable to keep floating in the air those corpuscles of every nature which are, as it were, the sediments of the atmosphere. If blown upwards, they drop again till they find strata sufficiently dense to "balance" them. Third,

the gradual elimination of the circumstances in which bacteria are engendered, thanks to progressive scarcity of centres of population. The progressive shrinking of earth surfaces as we attain high altitudes is another cause, till the zone of everlasting snows, when reached, by putting an end to all appreciable life, involves the total disappearance of any habitual source of infection.

As mountain-dwellers are mostly given to the pastoral life at those altitudes where agricultural pursuits are no longer consistent either with the climate or the nature of the soil, they are accompanied to their temporary summer homes by the insects which are associated with domestic animals. The horse fly *et hoc genus omne* are a plague to cattle even at an altitude superior to 6,000 feet. In Switzerland the mosquitoes bred in marshy patches of grass land and in stagnant waters under wood are met with in the early part of summer even above 7,000 feet. With a little systematic care, wherever they may trouble summer visitors in or near their quarters, it would be quite easy to get rid of them. Provided one's residence be an isolated one, removed from villages or cattle sheds, the objectionable breeding-places of house-flies are not difficult to detect and to rid of the pest. In a village it is practically impossible to exercise independent control over the surroundings of hotel buildings. The intervention of the local authorities would be desirable. This one is not likely to get, as the natives generally fail to see the necessity of any inspection. Dunghills seem to be inseparable from pastoral mountain life, and may even be an object of pride to their owners, who decorate them with plaited straw. Of course, the higher one goes to dwell the less one is troubled with the fly and mosquito nuisance, because the season propitious to them grows shorter and shorter. Of late, the winter fly, unknown hitherto, has sprung into being with winter hotels, which provide the unpleasant creature with the heat necessary for its untimely birth. They have but a short existence, in a weak and limp condition, and are confined to hot and closed-in spaces. Flies are quite easy to catch when newly hatched. They should be destroyed as soon as they appear, and then the inside of any dwelling-place remains free of that nuisance for the remainder of the season.

This matter of insect life is but a side-issue, while the outcome

of all competent observations is that from the altitude of some 3,200 feet, the air, tested in the open, contains very few germs of any kind and, consequently, extremely few pathogenic bacteria. Under those conditions, it is the contact of man that pollutes the air, and in this lies the essential and fundamental warning of hygienic law. At those considerable altitudes in which climatic health stations should be placed the natural purity of the air is tantamount to that obtained in laboratories.

It stands to reason that the almost complete absence of pathogenic germs from any given region must have something to do with an immunity to which other elements contribute. According to Dr. Regnard, the first to draw attention to this immunity was perhaps an Englishman, Raikie, who was a practitioner at Utakamund in the Neilgherry Hills (6,000 feet). Physicians practising in the Himalayas did also become aware of the same phenomenon, intuitively, as it were. On the Anahuac table-land phthisis was reported in 1861 as unknown. An equivalent assertion made about the Cordilleras gained currency in Europe in the following year. The table-land of Abyssinia and that of Thibet (notwithstanding the wretched stamp of population in the latter, owing to what the French call the state of *misère physiologique* consequent upon a wretched standard of living in a climate on the whole too extremely cold for human endurance) are other instances in point. Quite an encyclopedia of our knowledge on the distribution of diseases according to altitude and latitude was published in 1877 by Dr. H. C. Lombard in his *Traité de Climatologie médicale* (4 vols.), a storehouse of tabulated information and the work of a lifetime, to which those who have since written on the subject have not always acknowledged their indebtedness.

Physicians in the United States of America, thanks to the vastness of their field of observation, have obtained statistical figures which are more reliable than most. These show, in States rising from an altitude of 5,000 feet to 7,000, a proportion of deaths from pulmonary causes, which is about half, in fact, rather less than half, the proportion experienced on the flat-lands. On the Mexican table-land the lung cases of the general practitioner are about 2 per cent.

As for Switzerland, a systematic survey, which is the more reliable as it is not exactly recent and is consequently not "vitiated" by the importation of patients, shows that in this typical sub-temperate climate, if we mark by, say, eighty-six, the degree of infection prevalent on the lake level, it is reduced to fifty on the lower edge of the zone of comparative immunity, and sinks to forty above that line. Roughly speaking, to 112 deaths from infection at the lake level correspond seventy-one at an altitude of 3,600 feet, though, at that altitude, there are still large and extremely infectious centres of population. If we remove ourselves entirely from these (this is getting more and more difficult, owing to the rapid tide of civilisation which is now spreading throughout Switzerland and rising from the table-land to the highlands), we may quote the valley of Andermatt, in the times of its seclusion before the opening of the Gothard railway. At that time it was practically free from lung disease, and so was the valley of Goms (Conches), extending from Brigue to the Furka Pass.

In a preceding section, we spoke of the limit of cold in its effects pertaining to medical geography. We also said that the dividing climatic line between liability and immunity ran, according to some, at an altitude which is fairly intermediate between the sea level and that at which begins permanent snowiness anywhere. This limit is consequently at a lower altitude on slopes verging towards the north, just as it approaches the Pole much more than it spreads towards the Equator. At the polar circle, we have seen that the zone of immunity is brought down to the level of the ocean, but a little reflection shows that climatic immunity begins at the geographical point beyond, or above, which snow lies on the ground for at least half the year and under conditions of frost. Frost is comparable to pure air. Yet the votaries of pure air will have it that through it mountain life is in itself hygienic, and bestows upon man powers of resistance arising as it were magically or mystically, or at least inherent in air, such as would ensure health whether one lived properly or not. But we know that it is not so. The ordinary mountain-dweller is very liable to infirmities. Without much industry, depending on a sorry agriculture, he is unclean and rarely holds conversation with washing water.

He overheats and does not air his dwelling places. He lives in close promiscuity, not only with his kind and kin, but also with his cattle and fowls. Stable, pigstye, sleeping apartments, cesspool, kitchen, dairy and larder are generally thrown together within the least space possible. The windows are small, thickly glazed, and almost always hermetically closed. Current epidemics, such as whooping cough, do their work thoroughly under such conditions. Yet it is undeniable that in spite of bad life conditions, tuberculosis is practically unknown in such valleys as Avers, so high as which there is none in Europe. It is therefore made manifest that it is not hygiene that makes the mountaineer healthy, and that truly he is healthy in spite of the want of it, and this redounds remarkably to the credit of the climate.

The bad sanitary conditions of the born mountaineer cannot be altogether set aside in those Alpine stations where patients from other parts are collected. Yet the climate does take effect upon patients, even when they choose to dwell with and among the peasantry.

For this degree of immunity—and cure—there are at least two explanations.

However reckless of himself the mountaineer may be, he gets the benefit, whether he like or not, of at least one physiological characteristic of altitude : his blood is enriched. Under any circumstances, and anywhere, the full-blooded are not those who fall victims to phthisis. The full-blooded characteristics of properly-fed Swiss mountaineers are quite apparent to the observer. The physiological activity of their system is such as to combat both the effects of the cold and those of mechanical contagion.

The second explanation resides in this, that the rarefaction of the air, and, on the other hand, the overlaying of earthy surfaces by snow, along with the persistent cold, keep, in the first instance, surface germs from rising into the air. They are buried and chilled. In the second instance, they are less able to float and fly about in a rarefied air and are subjected therein, in any case, to meteorological influences unfavourable to the development of their virulence : intense frost at night and the purifying effects of intense light and heat during the day. To these must be added the dryness of the which, air whether

germs be burned by the sun or numbed, as it were, for want of it, is equally great by day and by night.

We are here in presence of an accumulation of effects arising from different, but co-incident causes, and this, as often happens, not only adds one virtue to another, but produces an effect multiplied and manifold.

Climatologists and physicians, since Lombard and Marcet, have gradually seen this subject pass out of the circle of their means of investigation and study into the sphere of strict scientific research in laboratories. The discovery of the bacilli of phthisis and pneumonia has brought the bacteriologist to the front, and the singling out of causes of health—and of ill-being—in the alteration of the blood is superseding the external diagnosis of physicians and general inferences of the climatic expert.

It is a matter of common knowledge that on the mountains the climate bears no close resemblance to that of the flatlands. While, during the month of August, dwellers on the banks of the lake of Geneva are stifled under a hot atmosphere, people residing at an altitude, within a few miles, enjoy a delightfully refreshing climate. Whilst the air is heavy and moist on the plains, it is dry and light on the heights. Whilst on certain days town and country are buried in low-lying mists or crushed down under impenetrable masses of cloud, the high Alps are radiant with sunlight showered down upon them from the depths of an azure sky. To give a personal instance, in 1913, the summer was generally damp, cold and sunless for the plain-dweller, while, at a suitable spot, my quarters were bathed in sunlight, with the exception of some seven or eight days, and that throughout summer and autumn. That the climate was generally unfavourable was shown by the failure of the vintage, and the same could be said of the summer of 1912.

In winter the contrast of plain with mountain is still more striking. In low lands, a damp and penetrating cold, under dark and chilly skies, any amount of germ-laden dust, whether wet or dry. On the mountain, in the shade, the cold is sharp and salubrious. Within an inch of that shade the sun strikes with burning rays a soil covered with a coating of light and dry snow. One experiences those delightful pricks of heat which

are characteristic of some of the best days on the Mediterranean. Now, this climate is *not simple :* it consists of an aggregate of elements and these we shall briefly review.

Barometric Pressure.—Of the complexity of mountain climate we first become aware by reading the barometer. To get together the bare altitude data of climate we have to consider height and place.

While on the sea level the glass shows 760 millimetres, the height being 0 ; in Switzerland :—

At Montreux, the glass shows 720 millimetres, at an altitude of 430 metres.

At Axenfels, the glass shows 700, altitude 655.

At Aeschi, the glass shows 680, altitude 886.

Now we rise above the belt of comparative immunity :—

At Chesières, the glass shows 650, altitude 1,245.

At Andermatt, the glass shows 630, altitude 1,494.

At Arosa, the glass shows 600, altitude 1,882.

At Arolla, the glass shows 590, altitude 2,016.

At St. Bernard, the glass shows 560, altitude 2,432,

and so on till we reach the highest extra-European altitudes. We need take no notice of altitudes which are not inhabited. So far as barometric readings are concerned, should we remain throughout our lives at the same place, yet do we change our altitude, as it were, with every change in the pressure of the air.

The lessened tension of the air brings down, as need hardly be emphasised, the boiling points of liquids. At St. Moritz, in the Engadine, the altitude being 1,850 metres approximately, and the glass therefore at 600, the thermometer will show the boiling point of water at 86° C., instead of 100° as at sea level.

The more rarefied the air becomes, the less perceptible to the ear are the waves of sound. The silence of high altitudes is most impressive. The scale of values being altered, sound acquires a character of solemnity which generally engenders a sense of quietude and awe which, in its complexity, may be compared to that felt in a cathedral. Some imaginations, however, are either too sensitive or too callous to find pleasure in this sensation.

The glass is *more stable* at altitudes than on the lowlands.

As on the seaside, its briefer compass of variation becomes then a much less reliable indicator of what people call weather. The reading of impending weather depends to a considerable extent on the stability of meteoric phenomena. These are much diversified at altitudes, owing to the marked differences in the relief of the soil and in exposure to the sun and winds. When not due to a general cause the quick termination of any weather may come quite unexpectedly.

Temperature.—As for barometric pressure, there is an observable scale in matters of temperature, too. As one rises on a mountain side shade temperature moves downward. But, here again, this is a law which, though scientific, is not of absolute regularity. To speak in averages, to an ascent of between 450 and 500 feet corresponds a fall of 1° C. in temperature. But this general law may be locally upset, when its very opposite may be observed, viz., a higher temperature as one rises and a colder air below. It is probable that at extra-terrestrial altitudes the temperature under 0 is uniformly higher than one would expect from the law of reduced temperature in proportion to altitude.

On mountain slopes, temperature rises or falls rapidly at any time of day or night. But it does not do so periodically, or so sharply in the morning or evening as on the seaside (for instance, on the Mediterranean, owing to the extreme shortness prevailing there in the transition from day conditions to night conditions). If twilight and dawn are longer the more polar the latitude, they are long in the Alps too. There is no heavy condensation of moisture after sunset and, the air being pure, there is no risk of either miasma or ague, as in southern maritime climates. Rarefaction, with concomitant dryness and absence of steamy dews, contributes to the healthiness of the Alpine heights. The rarer the air, the rarer the vapours.

The rays of the sun are darted down upon pronounced slopes at an angle which gives to the calorific and specific qualities of sun-power a greater strength. One might roughly compare to this the impression received from a fire as different from the action of diffuse heat. Calorific measurements of the rays of the mountain sun show that, both in themselves and by the great efficacy of their incidence, their chemical effects upon the

soil, plant life, and animal life are distinctly and deeply vitalising. Such effects must be wanting in northern latitudes in so far as rarefaction of both air and solar heat may be an aid in producing them. We do not know, for want of experimental data, whether the constant daylight of the northern summers does, or does not, make up for the obstacles opposed to the rays of the sun by density and the unrestricted thickness of air to be traversed. In any case we have seen that the impact of the sun is extremely oblique at the best of times on the polar flatlands.

WINTER.—The winter climate has now become the ruling element in the study of altitude as a sanitary agent. The climate of altitudes during winter, whether they are directly exposed to the rays of the sun or screened from it, came upon the generation that preceded ours as a discovery or revelation. Why, we do not exactly know; nothing has been changed in nature, but perhaps something new has come into man's appreciation of his relation to nature, whereby he is more inclined to look upon her as the great healer and physician. Altitude dwellers are subject to a climatic *régime* unknown to the vast majority of plain dwellers, and the statement of it struck the lowlanders as paradoxical till they had actually verified it.

Viewed as a physiological impression, the sense of pleasantness experienced at high altitudes is something *quite modern*.

In winter the floor of European valleys is very cold, and sunless as compared with the heights which dominate them. Upon the unfavourable impression formed in the valleys the Alps were judged, but falsely. Temperature is mobile, and its observation at the proper height has yielded since most salutary data. To be healthy, winter features must be very definite, else they are not conclusive. They are now known to be perfectly characteristic in the Alps above moderate altitudes, because the homogeneity of meteoric phenomena in their uppermost centres offers to the element of climate a field that is uniform enough for frequent repetition of the same satisfactory states of the weather.

In winter the air is in a state of unbroken calmness for prolonged periods. While these last the layers of air, cooled at

night, slip down along the mountain sides with the moisture they have collected, and then layers of greater density, charged with molecules of vapour under freezing point, hang and spread over the floor of the valleys. This fog floats at a certain elevation, and then, on the next morning, should the sun-rays beat upon the upper surface, it expands and slightly uplifts itself during the day, while at night it contracts again. Under this layer of mist, which may on the average be from 400 to 900 feet thick, extends a sunless, but clear, atmospheric area reaching down to the floor of the valley. This may or may not be covered with snow. In the latter case, the bare soil is likely to be frozen hard, in which condition the dust is slightly fixed at first, but is produced in ever larger amounts as time wears on. This feature, common to the whole Swiss table-land (the lowlands of Switzerland), is interspersed with spells of sunshine, rain, thaw and wind. This is the dominating climatic determinant in the winter life of four million people. This does not procure for patients coming from a distance the conditions which may restore them to health. These are found higher up, whence, however, mildness is excluded.

The reader may be acquainted with those old Italian paintings which show, in a diagrammatic form, Hell at the foot of the picture, our terrestrial abode midway up, and Paradise above. Well, a diagram showing at the bottom the lake and river regions, then the middle altitudes, would show the former to be separated from the latter by a thickness of cloud above which human beings, by piercing up through that layer, would emerge into Paradise. Such is the typical distribution of climatic zones in typical moments of the Swiss winter. At other periods, which come as breaks between those we have just described, the weather is not susceptible of any particular definition as Alpine.

Here is the order of the superposed zones :

1. Floor of the valley. Altitude from 1,000 to 3,000 feet.
2. A layer of condensation of moisture, may be 1,000 feet thick. May rise to an altitude of 4,000 feet.
3. Area of bright sunshine on snow surfaces, extending to the confines of peakland.

As long as the calm lasts *dusts* will congregate under the fog line, and the fog belt will deposit *rime.*

Now, as for temperature : several degrees of frost on the floor of the valley under the fog ; a damp cold within the fog bank where it abuts against each slope of the valley ; a sharp dry cold above the fog, so far as air temperature is concerned, accompanied by physiological perception of great heat during the hours of sunshine.

After this our readers will be able to understand how the following may be a true statistical presentment of simultaneous shade and sun temperature in winter :—

	Altitude.	Shade Temperature.	In the Sun.
Pontresina .	1,800 metres.	+ 26·5°C.	+ 44°C.
Bernina Hosp.	2,330 ,,	+ 19·1°C.	+ 46·4°C.
Riffelberg .	2,570 ,,	+ 24·5°C.	+ 45·5°C.
Hœrnli . .	2,890 ,,	+ 20·1°C.	+ 48·1°C.
Diavolezza .	2,980 ,,	+ 6·0°C.	+ 59·5°C.
Gornergrat .	3,140 ,,	+ 14·2°C.	+ 47°C.

The direct action of the solar rays determines the fact displayed by the above figures, viz., the extremely high temperature which a thermometer will note in winter, whether its bulb exposed to the sun is blackened or not. The therapeutic effects of this heat are necessarily great upon those who have contracted elsewhere those ailments for which such winter features are the appointed remedy.

We can here shortly explain why exposure to the cold, and perception of heat, are bound together as restorative forces at an altitude. The air is what is called diathermic. It remains at its own temperature while letting through the thermic wave. The calorific rays travel through it and fall upon the snow-covered ground, and this reflects the heat, practically without absorbing any of it. The cold air we *feel*, when we say it is cold. But let us place upon the snow a piece of paper or the merest dry leaf ; those bodies will intercept the calorific vibrations, give them storage and turn hot : a process which is made manifest by the melting of the snow lying under those screens and into which they will sink. If you touch those objects, your hand will perceive heat. More, if you place yourself as a recipient for the rays of the sun instead of any stone or leaf, you will perceive physiologically a heating process of which you are the seat. Not only do you then feel exhilarated in

mind, but your very marrow bones are instinct with happiness. The pure, subtle, cold air gives a sense of lightness to the warmth, and in this delight the memory of the troubles left behind melts away.

So, with or without clothes, the human body fulfils the same office as inanimate objects; it intercepts the direct solar vibrations and receives those which are reflected from the snow; it grows warm amid cold air.

A body at a high temperature in a cold and dry air, such is the characteristic of winter life at an altitude. So far as the sun is not sufficient to account for the whole process, the rarefied air intervenes. If we compare our bodies to the floor of the valley, the moisture on our skin surface represents the zone of fog, and what is outside our clothes a zone of heat, a drying room, in which evaporates—or in which sublimates—the moisture secreted by our skin.

Thus, it becomes clear that, at an altitude, if we may view the winter cold of the air at daytime as approximating the cold of the night elsewhere, we must confess first that dryness as a feature is not vouchsafed to night air in anything like the same proportion on the lowlands. In the second instance, the coldness of the winter air at daytime is made hygienic by exercise. Not only does it find a corrective to itself in its dryness and in the accompaniment of very strong sun heat, but also those features jointly neutralise the otherwise impoverishing influence of bare cold upon the system, and emphasise its beneficial effects as a tonic and germ-killer.

We should, however, not omit to say that, at an altitude, violent exercise soon brings on perspiration, for which there is a "call" in the dry air outside. Reduced atmospheric pressure, indeed, induces quick evaporation in such dry air. Consequently, the skin itself passes more quickly into a state of comparative siccity and the body loses in bulk what it gains in sudatory activity.

Anybody may become aware in his own person of the outer physiological signs of siccity. From the altitude of 5,000 feet the drying up of the skin begins to come within the perception limit of our senses. One's skin feels harsh to the touch, lips have a tendency to chap, one's hair gets hard and electrical, any secretions demand less urgent attention. Those that are

of a pathological description, such as moist eczema, colds in the head or even tracheo-laryngitis, dry up. This dryness so far is anti-infectious. A corresponding hardening of the skin, and even a thickening of its outer teguments, takes place in inurement to cold. The hair on exposed parts of the body grows in length and thickness. This may be noticed on the shepherds who move in summer to the upper pastures and are practically clothed in shirt, trousers, shoes only. Nature is able to devise protections against a dry cold. The sole of the foot becomes thicker, the exposed shins become furry. An extra layer of skin protects the finger tips and grows round the nails to a perceptible extent, till it becomes arid and comes off in flakes. But nature seems unable to devise defences against *damp* cold.

Another example of the characteristic non-infectiousness of dry Alpine air (wherein it tallies with desertic air) is furnished by the immunity from decomposition attending butchers' meat hung in the air, on condition that whole joints be protected from the direct action of the rays of the sun. Meat habitually dried in that way by the peasantry is as wholesome as if it were salted. If the meat is cut up into thin slices, it may be quickly dried in the sun without any inconvenience, beyond the reach of flies. It loses immediately its water, concentrates its juices, and could be kept indefinitely, but for its falling a prey in the end to disintegration. The peasantry will show cheeses that are 100 years old. We need not allude here to the preservation of corpses by exposing them to frost till the mollifying breezes of spring make burial or combustion desirable. Bodies may be indefinitely preserved in ice, or frozen in the soil. But Alpine air does not actually mummify.

At altitudes tickles in the throat and in the eyes result from the thinning of damp humours. Our laboratories and many industrial premises afford ample proof of similar desiccation in closed spaces or in spaces from which the damp air has been artificially removed.

The less the atmospheric pressure, the greater and quicker the evaporation. I have known it, in winter, to be so intense that I have seen the surface of the snow throw off moisture like smoke. This is immediately lost in the atmosphere, like the steam bubbling out of the funnel of a railway engine into

warm air, and then it again undergoes condensation as soon as it enters into contact with a cold stratum of air. At night, when the disappearance of the sun has cooled the layer of air immediately above snow in winter—the warm soil or rock in summer—moisture collects on those surfaces, instead of evaporating. Summer dew is uninteresting, but the collecting of rime crystals upon snow is a fine sight. They are sometimes an inch in length.

All this should not be taken to mean that fog does not exist in the middle Alps. It is certainly very rare in winter, but it is far from being unknown in summer, and it is most unpleasantly frequent in spring and autumn, when frequent thaws (spring) and the transition from the mean temperature above zero (autumn) to clear winter skies takes place under conditions which are not hygienic.

The moisture of winter fog is generally so rarefied that it goes under the name of dry fog. Such fogs do not wet and, in contact with surfaces, deposit their globules in crystalline prisms—for instance, upon one's hair and on vegetation.

Long periods of rain at low altitudes are frequent in summer and, of course, are a genuine hardship to those who have neither agricultural nor pastoral interests at stake. Conspicuous for dryness in the high Alps are the Rhône Valley from Martigny to Brigue and that network of valleys and cross valleys extending from the sources of the Rhine to Coire, with a culminating table-land in the Engadine.

High altitudes are free from rain in winter, which must be taken to mean that there may occasionally be rain above the altitude of 6,000 feet, even in mid-winter. This need be mentioned only on account of its very exceptional character. In summer, too, the higher we go the less rain. But most people are content to gain high altitudes in summer only because their mind is dominated by the analogy of what occurs in the lowlands where the summer is reputed the right season for out-of-door life. But this view is right only in connection with out-of-door pursuits such as agriculture and grazing, which are discontinued during the winter season. This interruption certainly applies to the highlander with still greater force and for a longer period. But the winter months are with him quite as suited to outdoor life, exercise and sport

as the summer months. And we do not hesitate to add that it is now a common experience that the winter season is even preferable in many ways to the summer season for the purpose of hygienic relaxation and restoration of health. What is wanted is to free one's mind from all the old-fashioned cant that connects every form of hardship and every danger to health with outdoor life at an altitude during winter.

The following tabular statement will give an idea of the rainfall in the Alps, as apportioned between the two principal seasons.

	Winter. Per cent.	Summer. Per cent.
Upper Rhine Valley	13	33
In the Upper Valley of the Reuss	15	36
On the Rigi	9	50
At Engelberg	14	40
In the Upper Aar Valley	18	33
In the Upper Rhône Valley	19	28
In the Ticino Valley	8	32
In the Engadine	14	34

The remainder of the percentage is fairly equally divided between spring and autumn.

It can be seen from the above table that the rainfall in summer is in almost every instance once again as large as in winter, that is, doubled. Of course, some of the rain that *should* fall in winter comes down in the shape of snow and covers the ground for a length of time, which may extend from one end to the other of the winter season. Of this snowfall we need take no account in this table, as it is snow, precisely, which gives to winter its characteristic of healthiness and marks it for outdoor life.

In winter, indeed, *snow* is the dominating meteorological element. It begins to fall in the month of October in small instalments, which soon disappear. Big snowfalls take place in December, January and February. They coincide on the whole with the corresponding rainfalls in the lowlands surrounding the Alpine range, and are no obstacle to outdoor life, except when accompanied by high wind. A snowfall may last from one to three days, and then will be followed by a period of fine weather which may extend to a fortnight and even last

three, four or five weeks at a stretch. For instance, the spells of fine winter weather were somewhat broken in 1911—1912; but in 1913—1914 they may be said to have lasted without appreciable interruption from the beginning of December to the middle of February.

The snows thus accumulated either melt, producing water, or else evaporate, passing directly into the air, without betraying the process to the human senses by any unpleasant impression or unhealthy influence. The latter is the case on sharply inclined slopes facing south, provided that the air temperature remains under zero centigrade throughout, so that the sun, though hot, cannot raise the temperature of the *snow* to thawing point. A coating of snow two yards thick may disappear within a month without a drop of water being seen, and leave the soil quite free from dampness. For this effect it suffices that the air should be very dry, the weather fine and the sky cloudless. Snow is not only frigorific, it sweeps the air clean and lays all the dust. When the soil is covered with snow the wind cannot raise any dust, and the result is immediately appreciated by those whose quietness of mind depends on the state of their larynx.

The *luminousness* of the Alpine air may be compared to that prevailing in certain regions of the East. This fact is due to its extreme purity and to the extreme scarcity of vapour it holds in suspension. This transparency is still greater in winter than in summer, and, in every season, brings despair to the heart of the painter, who realises his inability to express by means of opaque matter the degrees of that wonderful luminousness. On the shortest winter days the rays of the sun may be enjoyed in full south exposures from 8.45 in the morning (central European time) to 4.30 in the afternoon. At the altitude of 1,600 metres, the people stationed, say, on the Montana-Vermala slopes, may see from their bedroom windows the first rays of the sun strike the Mont Blanc range at 8.10.

The calorific *radiations* are of great intensity, as they are but arrested or feebly absorbed by vapour when travelling through the atmosphere.

Chemical radiation, too, is a phenomenon of greater intensity at altitudes. As an uninstructed operator every amateur

photographer has learnt that to his detriment, but also much to his delight, when he has seen the beautiful work he can produce without any particular attention, when once he has learned how to take advantage of the actinic qualities of the medium. Flowers are brightly coloured, though perhaps not more so than their congeners elsewhere whose particular characteristic is to be bright. Ladies, choosing for wear in the Engadine toilets in which the gamut of colours is carefully arranged for effect, soon find that the sun upsets all their pretty calculations, and that they stand clothed in oddly discoloured pieces of raiment. Chemists labouring in their laboratories to produce "fast" dyes, need only expose them to the winter sun, of Davos for instance, to feel the vanity of their endeavours.

Wind is a leading feature in Alpine climate. To escape from it, while remaining in stations fully exposed to atmospheric mobility, is one of the aims of the practical climatologist. In winter particularly the north wind is sometimes too bracing to be pleasant. But the country is so broken that wind can be avoided with the greatest ease. The native mountaineer understands this well. He not only builds his house where it is screened by woodland or a rocky belt, but will even point out to you on the most elevated mountain peak the warm nook where you may lunch and smoke in peace, with a roaring northern blast all about you.

The dry, hot wind, called "fœhn," swallows up moisture very quickly, and may eat its way through three feet of snow in less than twenty-four hours. The fœhn pumps up into the atmosphere an enormous proportion of moisture, and thus does away with its own aridity, ultimately bringing on floods of rain. The fœhn is the result of air currents rising vertically from the plain of the Po, and spreading far above the Alps, and dropping thence perpendicularly down the slopes. The characteristic of such upward—then downward—currents is to be cyclonic. Such cyclonic rushes may have their origin on the north-east side of the Alps, in the Val Telline and in the Tyrol, and their warmth may betray the unwary into assigning to them a southern origin. Their influence is very great on vegetation. To them may be attributed the quite abnormal flowering of the vine and ripening of its fruit amid the Pennine Alps.

The influence of the fœhn upon human beings, however, is

far from bracing. The most sanguine temperament experiences depression. Muscular effort becomes irksome. A kind of moral fatigue adds itself to one's physical "limpness." Headache may supervene, and the nervous system generally is ill at ease.

We may now sum up under six headings what we have already said in this chapter about climate and altitude. This does not at all mean that we have exhausted the subject, but it is advisable to have a kind of recapitulation before we proceed.

Firstly. Mountain air is rarefied ; for any given weight it contains less oxygen—and less of every other gas and vapour.

Secondly. It is cooler in summer than lowland air ; warm in the sun ; in winter it is *cold* in the shade, and *hot* in the sun.

Thirdly. The air is *very* dry in winter ; it is dry in summer, except during periods of rain, when it contains as much moisture as it can hold (less than in lowlands).

Fourthly. There is very little wind in winter, but violent wind storms now and then ; the air is characteristically calm ; in summer, on the contrary, breezes are habitual.

Fifthly. In summer, the earth's surface is cool and damp in woodland and on the grazings ; in winter the earth's surface is covered by snow, when the air is proportionately purer than in summer.

Sixthly. The intensity of sun effects is very great in all seasons ; the dry air is a good vehicle for the calorific rays of the sun ; hence the exceptional temperature generated on the snowy surfaces to which those hot rays are not only conveyed in great strength, but by which they are also strongly reflected into the immediately superposed layers of air.

Taken in the aggregate, those elements all concur in physiologically affecting human well-being in a favourable manner.

To those heads should be added the following *axioms* :—

At altitudes the atmospheric air is naturally light, naturally dry, naturally cold (not *cool*), naturally hot (not *warm*).

Whether the lessened proportion of each gas is a good thing *in itself* is still under debate. There seems to be no doubt as to the benefits accruing from atmospheric lightness, greater

dryness, greater cold, greater heat and better light. A consequence of the concurrent action of cold, aridity, heat and light in a *rarer* atmosphere is *purity*, freedom from germs and from contaminating dusts. This is worth paying for at a price, if the price exacted is merely the few drawbacks attaching to rarefaction. We shall see what importance may be allowed to those drawbacks within the limits of permanent residency at altitudes in Europe.

Dr. H. C. Lombard, who was to an earlier generation the accredited European expert on medical climatology, held that the deficiency of oxygen in the air at elevations (for which he introduced the word anoxhæmia to describe its effect on the blood) was, as it were, the specific anti-phthisic preservative, the cause of immunity from tuberculosis at altitudes and, consequently, its curative agent. Against this view Dr. William Marcet, a fellow-citizen of Dr. Lombard's, and a famous English experimentator and practitioner (the grandson of Dr. Alexander Marcet), brought up his own observations carried on in Switzerland, on the peak of Tenerife, etc., to the effect that rarefaction was a sanitary agent by respiratory stimulation and that, consequently, it was the heightening of vitality that counteracted consumption. Dr. Marcet has turned out to be right. But Dr. Lombard's climatological law that acclimatisation to *cold* brings on hyperæmia (full-bloodedness) subsists. If we remember that clean cold air is enough to paralyse the bacilli that are about, he accounted correctly for the check upon phthisis in northern latitudes. It has since his time become unnecessary, for an explanation of immunity at sanitary altitudes, to have recourse to the depressive agency of want of oxygen (anoxhæmia).

The fact to be borne in mind and which Dr. Lombard did not distinguish sufficiently, is that, as there is sanitary cold and unsanitary cold, so there is sanitary altitude and unsanitary altitude. At the former the blood is fortified, at the latter it is debilitated.

We shall therefore have henceforth to distinguish : enrichment of blood at altitudes (we do not think that these can exceed 10,000 feet, even under the most favourable circumstances of latitude) and impoverishment of the blood, which certainly begins for most people at altitudes from 8,000 feet

and is a particular feature of altitude within the tropics. To distinguish between those two conterminous stages is a task that falls within the province of organic chemistry, *blood* chemistry, and is a new science (hæmatology). Nothing that climatologists, pure and simple, have written or discovered since Lombard and Marcet has marked an improvement upon the positions of those eminent physicians. Appropriate altitudes are a means to health. High altitudes are a test of health.

The hygienists and sanitarians of two generations ago were quite as slow as any medical men in realising the significance for health of the winter sun in the mountains.

> " O, who can hold a fire in his hand
> By thinking of the frosty Caucasus ?
> Or wallow naked in December snow
> By thinking of fantastic summer's heat ? "

do we read in Shakespeare's King Richard II. Such was the mood they had inherited. Yet there is in the wonderment of Shakespeare the tone of premonition and anticipation. Those frosty fires are now experienced and children "naked in December snow" snap their fingers at "summer's heat."

CHAPTER IV

The meteorology of the Alps—Refrigeration—Inverted temperature—Sunniness and cloudiness—Thermometer readings—Soil temperature—Exposition—Night, shade, and sunlight conditions—Intermixture of the seasons—Snow, wind, rainfall and snowfall—Reviewing the characteristics of Alpine climate at the higher curative altitudes.

With a view to determining the depth of snow which may be expected at a series of altitudes, we may quote the figures referring to the Val d'Entremont for December, 1913. This is a long valley running up to the St. Bernard Hospice. Its southern latitude, combined with its exposition to the north and distribution in successive terraces, makes it quite typical.

When at Martigny (altitude 1,560 feet) there is a mere sprinkling of snow one may expect at Orsières (2,900 feet) half a foot; at Bourg-St.-Pierre (5,350 feet) 2 feet; at the Great St. Bernard (8,100 feet) 7 feet of snow. These figures may safely be assumed to apply to the whole of the middle and high Alp ranges, within the limits of habitableness.

In the Alpine region the average barometric pressure moves between 626·5 and 564·5 millimetres. At higher altitudes, say, at 3,500 metres, it may be 497 millimetres, and at an altitude of 4,000 metres it would be 466 millimetres. This means, for human beings, an air pressure that is at least 136 millimetres less than on the sea level. The direct influence of this reduced air pressure is, from the mechanical point of view, not worth considering. But it has its say, indirectly, because the effect of thinner air upon radiation and upon evaporation is of great importance to the human body.

The exact laws of refrigeration with reference to altitude are as follows: The fall of the mean annual temperature in the shade for every hundred metres added to altitude may be fixed at 0·57° C. for mountain ranges situated out of the tropical zone and up to the sixtieth degree of northern latitude. This means that each time we move 170 metres higher, we find ourselves removed to an average annual temperature that is reduced by 1° C.

The loss of temperature in winter is *slow* as compared with summer. In winter we have to rise 220 metres to lower the temperature by 1° C. In summer an ascent of 140 metres is enough for this. The contrast between mountain and valley is sharpest in spring, in May and June, because, at that season, the sun warms already the soil in the valleys, while above, the snow still lies, or fresh snow falls, the melting of which consumes much longer the calorific rays of the sun. The shade temperatures of mountain and valley are nearest to each other in the middle of December and thereabouts.

The Alpine summer shows a greater difference with flatland summer, in temperature, than the Alpine autumn differs from flatland autumn. At an altitude spring is late, but autumn comes early.

In winter, as we have hinted before, the law of falling temperature with every rise in altitude, is frequently reversed for long periods, whatever tables of averages may say.

The following figures, noted *before* sunrise on the *same* day, in the *depth* of winter, are instructive. The places are at no considerable distance from one another.

	Altitude.	Temperature.
Altstætten (Rhine valley)	480 metres	—12·7° C.
Trogen . . .	890 ,,	— 3·9° C.
Gæbris . . .	1,250 ,,	+ 3·4° C.

Further rises in altitude might show increasing warmth. The cause of this is that layers of warm air located high up in the atmosphere do, under the circumstances noted above, affect favourably the temperature of the higher regions. The mechanical process of friction going on in the air itself—the downward rush of night air—raises the temperature on the peaks and down their sides to such a point that the upper inhabited region gains therefrom the paradoxical benefit noted above. The air remains warm no lower down than the upper winter fog limit, where it rests and experiences a sun-bath during daylight and rises again. Endless snowfields doing duty as reflectors with the upper surface of endless sheets of lowland fog, innumerable peaks with their faces turned south doing duty as hot plates—such is the provision made for an immense syphon-like circulation in the becalmed winter air. This phenomenon science has recorded, but not yet fully

accounted for. We thus get a see-saw *régime* above the fog quite distinct from that which prevails underneath. Consequently, whenever the Alpine plants are so situated that they can break through the snow surface and get the sun, those that are normally due in spring, as we flatlanders call it, produce leaves and throw up flowers in the summery conditions of mid-winter and then pass through comparatively severe weather in the orthodox spring season.

Another way of illustrating this law of *inverted* temperature is to quote the following simultaneous readings :—

	Altitude in Metres.	Temperature.
Bevers (Engadine) .	1,715 (valley)	—10·1° C.
Rigi-Kulm . . .	1,784 (open skies)	— 5·1° C.
Julier Pass . . .	2,224 (neck)	— 8·8° C.

The exposition on the Julier Pass means a *draught*, that on the Rigi means up and down displacements of the air, that of Bevers implies accumulation of cold air within a protective belt.

So, in a sense, in winter, the more open the site the warmer, notwithstanding that the range of temperature appears low down on the thermometric scale. The day and night extremes may be wide apart, ranging sometimes from — 30° C. at midnight to + 50° C. in the mid-day sun. Yet the winter and summer opposition becomes gradually of less moment. At Altstætten, for instance, the warmest month and the coldest diverge in temperature by 19 degrees ; at Trogen, by 17 ; on the Rigi, by 14·5 ; on the Sæntis, by 13·8 only. The more one rises, the more do the readings reduced to each seasonal middle rate show the relative uniformity and steadiness, throughout the year, of shade temperature in the air. It then becomes a matter for calculation at what altitude seasonal differences might be cancelled. Balloonists rising to an altitude of 7,700 metres have noted in May an air temperature of — 36·5° and in December — 38·5°, which, in ordinary parlance, would bespeak perpetual winter. In fact, mountain peaks "run through" the four seasons in one rotation of the globe, one revolution of the sun.

With the thermometer showing, say, + 40° C. on its sun-exposed face, and — 40° C. on the shade side, every speculation becomes possible. One may picture a revolving human body suspended aloft, and carried along round the globe at a speed such as would keep it out of the cone of darkness projected

from the planet, with no other shadow than its own. Such a body would be by no means impervious to heat. To no avail would a thermometer register in its shadow 40 degrees of frost, when on the sunny side an equal number of degrees of warmth were shown. Assuming that this temperature balances its opposite terms at zero Centigrade, bodies in such extra-terrestrial situations need only be clothed, fed, and their breathing provided for as here below, to keep their blood temperature at the normal pitch. Barring flights of fancy, the physical cold of the atmosphere is not such that the sun could not supply a sufficient quota of heat for life. At the moment of writing, the aviator Parmelin had just overflown Mont Blanc, from Geneva to Aosta, reaching an altitude of over 5,000 metres. Well fed, well clothed, and well supplied with oxygen, he began to inhale his portable breathing stuff on reaching the altitude of 3,000 metres and did not lay his nose-bag aside till within 2,000 metres of his landing place. What with airships, aeroplanes and such speedy aircraft, we may anticipate almost scientifically the moment when, supplied with a sandwich and a small flask of oxygen, we shall fly under the eye of the mid-day sun, casting down our little shadow perpendicularly to the ground, at any altitude above sea and land, at a higher rate of speed, maybe, than that of the earth's rotation on its axis. Sixteen miles a minute would do it and leave a margin.

Between seasons, enclosed valleys and table-lands show a much more extensive swing of the pendulum than mountain tops. In the case of the latter the climate is "aërial." Their air collects less heat in summer and stores up less cold in winter. Mountain-girt high-valley health stations, such as Sils and Bevers in the Upper Engadine, show a swing of temperature which is by 6 degrees wider than that prevailing on the Rigi-Kulm at the same altitude.

Insolation (that is the increase in the amount of intensity of sun exposure) grows with altitude. We mean by insolation the total effect proceeding from the sun rays when striking any given surface. This effect may be scientifically measured. While travelling through the atmosphere, any given sheaf of rays loses a proportion of its vibratory heat by absorption in the air and in atmospheric vapour. Hence its heating effect

on the solid objects that it strikes decreases in ever greater proportion as the layer of air that it traverses increases in thickness. When the rays of the sun have travelled through the whole of the globe's atmospheric belt down to the sea level, something like 32 per cent. of the inherent and communicable heat has been used up on the way in raising the temperature of the air, so that at least one-third of the radiative efficacy is no longer available for the penetration of the human body. It would appear that on the top of Mont Blanc, at an altitude of 4,810 metres, solar radiation has yielded to the air only 6 per cent. of its heating power ; at an altitude of 3,000 metres the loss is 11 per cent., and at an altitude of 1,200 metres the deficiency is 21 per cent.

If the heat available for penetrating the human body on the sea level, with the addition of reflection from the sea surface, is only one-third of the heat that would be available on the upper confines of the atmosphere, one may easily picture to oneself what comfort exposure to the sun rays on high mountains must bring to people of lowered vitality.

Scientific observation shows that one and the same object, exposed to the sun on the seaside, and then at an altitude, will show a greater heat at mid-day in the latter situation.

The blackened thermometer is known to show 101° C. in mid-summer in Thibet, a temperature which considerably exceeds the boiling-point of water at the same altitude. Also, it is now admitted that the dark pigmentation of the skin, which is an effect of direct exposure to the sun, is a preventive against the radiation of blood-heat into circumambient air. Such pigmentation is both a result of exposure and a protection against the risks attending exposure, namely, damp on the flatlands and actual cold on the highlands.

The rays of the sun are not indiscriminately or equally absorbed by solid bodies. Certain elements in the spectrum resist absorption more than others. Ultra-violet rays, occupying the more easily refracted region in the spectrum, are very considerably absorbed, particularly by the lower strata of the atmosphere. Hence, in the Alpine air, a comparatively large number of such rays are still unabsorbed and available for plant and animal life. Thus intensity in irradiation makes up for any want in air temperature, while such intensity, from the

physiological point of view, is palpably far more hygienic than atmospheric warmth measured in the shade, or bereft of the better ingredients in solar radio-activity. Shade is a state; sunlight is a force.

In seasons whose general characteristic is cloudiness elsewhere, the Alpine climate is distinguished by the serenity of the winter skies. Cloudiness should not be confused with mistiness or fogginess. The former means simply the screening away of sunlight by high-lying masses of condensed moisture. The latter implies direct contact of the human organism with the areas of condensation or floating dusts.

If we represent by the figure 7 the average cloudiness registered at an altitude of 400 metres, we find that it is reduced by more than two-sevenths before we can reach the altitude of 2,500 metres; this in winter. In summer, an exactly opposite process takes place (low altitudes).

Let us now see what occurs with respect to fog. At low altitudes the spring and autumn clouds of seaside and flatlands make their presence felt as local fogs or mists hanging on the hillside. In summer, which is the actual rainy season in subtemperate altitudes, cloud and fog combine their effects.

But, in compensation, sunniness, which is the antidote to cloudiness and fogginess, shows on the mountains obedience to a very different *régime* from that which holds good on the plains.

In the Alps it is the winter that is the most sunny season, not, as in the flatlands, the summer. Between eleven and one o'clock in December, we may reckon twice as many sunny hours, at an altitude of 2,000 metres, as at Paris or Vienna, then buried under leaden skies. Paris and Vienna have their sun in summer; say, in August, sixty-six hours of sunniness against twenty-one only in December, measured, as pointed out above, from eleven to one. In other words, the Alps enjoy, above the fog belt in winter, on an average, full sunshine on every other day, while elsewhere the most favourable hour of all is not sunned upon as much as once in three days. If we are to confuse cloudiness and fogginess—and this we may fairly do in speaking of altitudes throughout the spring, summer and autumn months—the comparative absence of sunshine and comparative increase in raininess does tell unfavourably upon Alpine summer resorts, but then there is the fact that the comparative coolness

accompanying altitudes under such circumstances is exactly what people seek when towns and the seaside are smothered in summer heat.

The intensity of *insolation*, the decisive factor of Alpine climate, exercises an influence on the temperature of the soil as well as on that of the air.

The warmth of the soil is in the Alps comparatively greater than in the plain. Everybody knows that the ground gets everywhere warmer in the sun than the air. In mountains the excess in warmth is considerably greater. In figures we may say that the soil is warmer than the air :—

At an altitude of		1,000 metres	by	1·5° C.
,,	,,	1,300	,,	1·7° C.
,,	,,	1,600	,,	2·4° C.
,,	,,	1,900	,,	3·0° C.
,,	,,	2,200	,,	3·6° C.

The effect of this difference is fully realised by those who, after taking a bath in an Alpine lake at the latter altitude, lie down unclothed on the hot short grass. The delight of hot bath towels, after a plunge in the *frigidarium* of a Turkish bath, is nothing to the contact of dry, hot turf in thin air when a blazing sun beats upon one's naked body. In winter the ground, as soon as it is unfrozen, actually trickles with hot water, and this, as soon as the source of it is exhausted, dries up with a speed that transforms in a few hours a sodden slope into a parched desert. Observations in the Engadine have shown, with an air temperature of under 2° C., a temperature of + 5 at the depth of 2 inches under the surface of the soil (average figures).

The heat of well-exposed and well-screened-off regions increases in proportion to altitude. At the height of 3,000 metres the warming of the windless air by heat reflection *from the ground* will be found three times as great as in those layers of the air subject only to direct insolation. Moral : the more fully you expose your body to the sun while abandoning the vertical position, the greater will be the distribution of heat throughout your system. Human physiology, like that of plants, works itself out more completely under the influence of solar heat and strong light, if it may also enjoy the warm

effluvium of Mother Earth. In this we note one of the chief differences between the Alpine and Arctic climates. Dwellers in the extreme north vegetate, rather than live, through a winter relieved by a few pale summer weeks under an atmosphere almost bereft of light and of heat. The Alpine dweller has a summery winter, daylight on all days of the year, nights free from mists, a cool summer and quick daily transitions from an efficacious sun heat to an efficacious night refrigeration. In the north the midnight sun cannot make up for the feebleness of the illumination, the temperature of the ground does not rise above that of the air, the soil remains for ever frozen at the slightest depth, and bathed in vapours.

Another consequence of intense insolation is the great difference we note in local climate according to exposition. Sun and shade bring about in the mountains strong climatic contrasts within extremely limited areas. A suitable example of this, out of thousands, may be quoted here. The Valley of Findelen, above Zermatt, runs west and east. On the slope facing north the vegetation is that of the Siberian *Tundra ;* on the other, cereals ripen at the altitude of 2,100 metres, and the vegetation is that of the arid barren tracts on the Mediterranean border. Between those opposed slopes the air-distance leaves an interval which a well-aimed stone could traverse. The difference in climate, expressed in degrees of latitude, would be equal to thirty or forty degrees, that is, the distance from Iceland to the rocks of Gibraltar.

At an altitude, say, of 1,000 metres, the mean difference in warmth measured *on the soil* in the Alps, according to exposures (faces), works out as follows in standard figures :—

	Annual Average.			
South-west face .	+12·7°,	rising in summer to		+18·3° C.
South-east face .	+12·6°	,,	,,	+19·7° C.
South face .	+12·6°	,,	,,	+19·3° C.
West face . .	+12·2°	,,	,,	+18·5° C.
East face . .	+11·3°	,,	,,	+18·6° C.
North-east face .	+10·6°	,,	,,	+17·0° C.
North-west face .	+10·2°	,,	,,	+16·0° C.
North face .	+ 9·5°	,,	,,	+15·3° C.

If the corresponding figures had been worked out for an altitude, say, of 2,000 metres, the contrast in soil temperatures would have been still more striking. As we rise higher the variations in the snow-line, too, show the curves one might expect, as the exposure changes with the "lie of the land." The snow-line may dip locally and rise again suddenly with a range of 500 to 700 metres between the extreme points, in spring and in early summer, till the much more equal warming of the air from the summer solstice onwards stabilises that limit by the complete disappearance of those winter snows which have fallen in excess of the quantity permanently allowed for by the combined effect of latitude and altitude.

The intense insolation of the middle and high Alps has its counterpart in the opposite process that takes place at night by centrifugal radiation of the day's accumulation of sun heat. This latter phenomenon, the reverse of the former, results from the same cause, viz., the rarefaction of the atmospheric envelope of our globe. The efflux of heat at an altitude of 2,500 metres is, for instance, greater by about 37 per cent. than on the Swiss lakes. Half-way up Mont Blanc it is almost twice as great as at Chamonix. In consequence, bodies—this is of importance to human and vegetable physiology alike—experience cold nights after hot days, and, we may say, the better the exposition from the point of view of warmth during the day, the more severe it becomes, by contrast, with reference to cold during the night, unless the air is sheltered by being enclosed (caves or artificial cavities). If we have kept in the shade—as in the case of northern expositions, which receive the least sun throughout the day—the change will not be so *violent*, shade being the more constant factor, but the constant northern exposure is the more severe.

To return to averages, the difference of the shade conditions between the warmest and the coldest hours of the day, measured at the altitude of 400 metres, shows, year in and year out, a range of 7° or 8° C. Still keeping to shade conditions, the difference between the hottest and coldest hours, at an altitude of 2,000 metres, will be two degrees only; at 3,000 metres it is still less. Thus, as we rise, shade temperatures become more even throughout, while if we compare, under south and south-west aspects, average night temperature and average sun

temperature, the difference grows greater and greater as we rise. A graphic way of putting this is, that under such conditions you may enjoy a hot cup of coffee while lounging in the sun, but, if by any chance the shadow of your body falls upon the cup, your drink will be iced instantaneously.

These explanations are necessary to make intelligible to our readers the all-important difference between biological and meteorological climate. Strange to say, quick alternations of climate are as conducive to exuberant life and growth as a quiescent climate is depressing for man and beast. Stimulation is the essence of life, and, in this respect, the best conditions are those which are less durable and ensure, as it were, the vibration of the pendulum of health from one set of circumstances that are termed favourable to another set that may be different or even contrary, but are none the less just as fundamentally salutary and apt to call forth the fullness of physical vigour and physiological animation. A good biological climate is one that favours activity, the meteorological ingredients of which must be preferred to those climatic factors which induce passivity or make for duration alone. "A short life but a happy one." Of this philosophic doctrine vegetation in the high Alps shows within the compass of its short summer a literal application. Up there life is bright, irrepressible, and, by perpetual renovation, meets the demand for duration without reducing itself to passivity. Vegetable sap is almost boiled during the day. During the night it owes to its peculiar composition that it is not frozen out of existence before sunrise. It is with the mountaineer as it is with the *flora* of the high Alps. His outdoor life is fuller. Some would have it that it is shortened by a more rapid organic combustion and the wearing out of the human material. But statistics show that the span of the mountaineer's existence is quite as long as any other.

Snow may fall at any time during the summer at any altitude down to 1,500 metres. From that altitude upwards spring and autumn conditions are woven into the web of summer. *Vice-versa*, winter conditions penetrate both the autumn and spring months.

Subject to these reservations, the Alps may be assumed to be free from snow :—

For 9 months at the altitude of 600 metres (March—Nov., both inclusive).

8	,,	,,	1,000	,,
6	,,	,,	1,500	,,
5	,,	,,	1,800	,,
4	,,	,,	2,000	,, (highest cattle grazings).

Under a northern aspect the soil remains on an average covered with winter snow for a period that is eleven days longer for each rise of 100 metres. The Alpine summer is thus shortened by from nine to twelve days for every change of 100 metres in altitude.

The temperature at which the melting of winter snow takes place rises with altitude. At an altitude of 1,000 metres the winter snow is removed by the end of March, showing an *air* temperature of 5° C., but when it melts :

at an altitude of 1,500 metres the *air* temperature is 6·2° C.
,, ,, 2,000 ,, ,, ,, 7° C.

These figures show plainly what experience teaches : namely, if for health reasons you are within the Alpine tract in winter, it is better to rise during the melting of the snow than to move down the valleys—either go higher up or move quite out of the melting zone. At middle altitudes the transition from winter to spring and early summer is slow and rainy, as it obviously must be with the mass of water sent down from the upper reaches. But in those reaches the melting process is put off long enough for its speed to be very great, and the trying intermediate period is reduced to a minimum. The god of spring moves up the Alps at a rate which it is unpoetic, but scientific, to express in figures. It takes him from seven to eight days to ascend 100 metres, and, consequently, he employs something like six months, starting from the altitude of 600 metres, to reach that of 3,000. When he has reached it, autumn drives him away almost forthwith, and the winter god steps down from the glacier region at the rate of about 200 metres per week.

The Alpine summer is short, it sets in late, it is broken by frequent snowfalls, and a frosty night may at any time blight the finer vegetation.

On the Sæntis, altitude 2,500 metres, the months of July

and August show frost on ten nights. So far as plant life is concerned, the insensibility of Alpine plants to frost is such that their physiological life enjoys sufficient immunity from the effects of such sudden changes from violent cold to furious heat. They freeze, thaw and bloom within twenty-four hours. The genuine Alpine *flora* knows little of our orthodox seasons. The plants remain green and full of sap under the snow. No wind, a tepid air, a warm soil, a bed of dry grass. Let a hot waft melt the roof of this snuggery : in comes the sun, and in that niche it is summer. A week later the lid is closed up again, and if the plant could read the calendar it would see that it had mistaken the winter solstice for the spring equinox. Man may expose himself to the same physiological awakening !

The *speed* of wind increases with its greater *lightness* as altitude increases. At an altitude of 400 metres we may state it to be from 3 to 4 metres per second (annual average). At an altitude of 2,000 metres the average speed is set down at about 6 metres, and from 3,000 metres upward it reaches and exceeds 9 metres.

We have no concern with hurricanes ; these are no particular feature of Alpine meteorology. But the regular downward and upward breezes of day and night have an influence upon nebulosity. Upward day wind produces condensation and accounts for the late afternoon showers that are frequent throughout the summer, not rarely in the shape of thunderstorms. In winter the corresponding phenomenon takes the shape of a deposit of rime after sunset, thus freeing the air from moisture. The night wind brings cooler air, in summer, into the concavity of the valleys, except when it is a "fœhn" wind, in which case the night air becomes enervating. The higher the altitude, however, the more are the objectionable features of "fœhn" removed.

The capacity for *vapour* (moisture) *decreases* very rapidly with altitude, and in proportion to the lowering of the average temperature of the air. At the altitude of 2,000 metres above the sea one has below oneself half the aqueous mass contained in the atmosphere ; at an altitude of 4,000 metres, three-quarters, and by the time one reaches 6,500 metres, at least nine-tenths of the total dampness our atmosphere can carry is under one's feet. Hence the transparency and purity of the

air in the high Alps, to which intensity of insolation brings an appreciable increase.

If we are now to dwell upon comparative moisture, that is, to consider in its various degrees the state of saturation in which we may find the air, we must begin by laying it down that, in this as in other respects, the Alpine climate is characterised by rapid passages from one extreme to the opposite. For days mist may hang about the heights, the air is saturated with vapour, and suddenly a rift in the clouds heralds extreme dryness. At high altitudes then the atmosphere shows an exceptional faculty for saturation and evaporation, a faculty that is far in excess, in speed and in thoroughness, of what we meet with elsewhere, owing to the thinness of the air, its agitation, and the activity of snow and ice surfaces as condensators. Even should we assume, for argument's sake, an equal tenour of moisture at all altitudes, an equal temperature and a wind of like strength, yet, in consequence of reduced air pressure, the evaporation must be much greater per cubic air-volume on high than on low levels. Perspiration is soon absorbed, one's skin gets rough, and thirst is frequent. We have seen how the drying of butcher's meat in the air is a typically Alpine process of preservation, the exact opposite of, and yet identical in effect with, that of "tinning" a hermetically closed liquid or jelly. The Alpine *flora* is instructive in this respect. The highest rock-plants appear in the shape of tiny cushions with thick, succulent leaves or closely-packed needles, the latter acting as a barrier against penetration by the sun, and the former storing up moisture.

If we may compare the Alpine tract to an island, or rather a chain of islands, stretching in the form of a long-drawn crescent across the continent of Europe, we shall be entitled to say that this rope of islands is a rainy tract. Mountains are condensers of vapour in this, that they oppose a barrier to wind-borne moisture and bring it down. The fullness of vegetation and the humidity following upon this phenomenon lead to its frequent repetition and magnitude.

The qualifications to this general rule are that, on the one hand, the rainfall increases in some ratio up to a certain altitude, while, on the other hand, it gradually decreases above that altitude till it is practically reduced to nothing. The incapacity

of the atmosphere to hold moisture at high altitudes is the cause of this seldom noticed reversal. In the Alps the rainfall is at its maximum at an altitude which we think is somewhat under 5,000 feet.

In connection with this it will appear that, according to the seasons, the height to which clouds may rise undergoes periodic variations. In winter the cloud belt is rather low. In summer their encircling masses rise higher. The sunny winter skies of the high-lying valleys of the Alps, say, from 1,300 to 2,000 metres, are a consequence of this general swaying of the cloud line in the vertical. To get a striking example of this we may look to central Asia, where the scale of levels is of a magnitude unknown in Europe. In central Asia the ring of snow-laden clouds is suspended at an altitude of from 2,500 to 3,000 metres. The region that extends above this belt receives from the *summer* clouds—which rise higher—plenty of rain, and this produces plenty of grass. Then the natives move with their herds of horses up to the table-lands at an altitude of from 3,400 to 3,700 metres, and there they find grazings in the pink of condition, the way up to these leading by that time through deep snow. Such high-lying grazings, water-fed in summer and shone upon by the sun in winter, because they lie higher than the belt of fog can rise, and yet are under the limit of everlasting snows, correspond exactly to the grazings of Switzerland, the forest zone, instead of snow, being crossed by the cattle.

The high Alps are snow-covered during a prolonged winter (from seven to nine months), and the coating is deep. Above the tree-limit snow accounts for about 40 to 70 per cent. of the year's total fall. If we average throughout a series of winters the falls of fresh snow we find figures as follows :—

	Altitude.	Total of Gauged Snowfalls.
Davos	1,560 metres	5 metres.
Græchen (Valais, dry) .	1,632 ,,	3 ,,
Bevers	1,710 ,,	4 ,,
Grimsel	1,874 ,,	17 ,,
Gothard Hospice . .	2,100 ,,	13 ,,
Gt. St. Bernard Hospice .	2,478 ,,	9 ,,
Theodule Pass . .	3,333 ,,	2 ,,

The figures in this table are sufficient to prove two points. First, that the biggest snowfall does not take place at the highest altitude. Above 3,000 metres it is actually very slight. Second, exposition has something to do with the snowfall. Of this the example taken from Græchen in Nicolaïtal (Zermattertal) is conclusive.

Readers of my book, "Ski-runs in the High Alps," have found in its pages abundant proof of the comparatively very slight snowfall to which are exposed in winter the peaks of the Alps, a fact which makes their ascent practically as easy in January or February as in July or August, now that sportsmen understand the facilities afforded by ski to cross the enormous masses of snow accumulated between the lower inhabited zone and the altitude at which the zone of everlasting snow begins. It is a striking fact that the zone of everlasting snow is much less snowy than the regions from which the summer's sun has power to entirely remove the snow. This fact, for the full discovery of which I claim credit, bears very adversely upon current ideas on the formation and "nutrition" of glaciers.

Recapitulation.—In his book, published in 1904 under the title "Plant-life in the Alps," Professor C. Schroeter, of Zurich, after dealing from the purely botanical point of view with much of the foregoing matter, sums up as follows: For every difference of 100 metres in height the meteorological modifications are that (area of Alpine *flora* and *fauna*):—

The average annual air temperature is reduced by 0·58° C.
The average summer air temperature is reduced by 0·73° C.
The average winter air temperature is reduced by 0·45° C.
The beginning of spring is delayed by 7·6 days.
The winter snow sets in earlier by 3·8 days.
The season of freedom of the soil from snow is shortened by 11·5 days.
The appearance of vegetation in spring is delayed by 4·1 days, while the autumn phenomena of vegetation practically remain contemporaneous with phenomena of the same order on the plains.

The principal characteristics of Alpine climate may be

summed up under the following headings, in plain language and irrespective of any scientific phraseology :—

Air Pressure.—The pressure is low (thin air).

Temperature Conditions.—The range of average temperature of the year is placed low on the scale ($-14°$ to $+2°$ C.). The amplitude of temperature is less (the *winter* is comparatively warm).

Strong insolation during daylight and strong dispersion of heat at night. Hence much amplitude in the temperature of *heatable* objects (in spite of a very limited range of *air* temperature in the shade).

A comparatively high temperature of the *soil.*

Extreme variations of temperature according to *exposition.*

Luminousness.—The light is intense.

The proportion of ultra-violet rays is greater.

The winter skies are remarkably sunny, particularly at mid-day.

Period of Vegetation and Frost.—The period of vegetation is shorter than in the plain, lasting from five months to six weeks only.

Vegetation sets in *later* with the benefit of long bright days and subject to short cold nights.

The temperature of the air is high when the vegetation period sets in, and this corresponds with the quick melting of deep snow.

Even during the Alpine summer, snow and frost do occur with very low thermometric readings.

In places free from snow vegetation takes place even in winter, thanks to the increment in insolation.

It is unnecessary to dwell upon those references in their bearing upon human health. Their significance is obvious.

Wet, Moisture and Snow.—The quantity of water in suspension in the air is very considerably reduced. Hence mountain air saturated with moisture contains less of it than the same volume of air would contain at a low level.

In *relative* dampness the air passes rapidly and frequently from one extreme to another, from the degree of absolute saturation to the maximum of siccity.

Greatly increased volatilisation of water (evaporation).

Increased rainfall during the three milder seasons up to

1,600 metres with sudden decrease from that altitude, then summer rains only and winter snows.

A deep snow-covering for the soil throughout winter.

The formation of mist, fog, and clouds is shifted to another period of the day and of the year, the maximum being in the afternoons, and in the three milder seasons.

Motion of the Air.—A comparatively great average speed of the wind; windless periods in winter.

Daily alternating up-hill and down-hill breezes.

Comparatively great temporary increase in warmth and aridity through "fœhn," wind of great violence, followed by a big discharge of collected moisture. Sharp north winds, dry and sunny. South-western gales. Marked upward and downward streaming of air, with contraction and expansion in keeping with the ranges of temperature traversed.

Animal Life out of Doors.—For human life the strongest sun effects, per day, are available in winter, which is also the longest, driest and genuinely cold season. Summer is comparatively short, damp, and warm or cool according to locality. Winter makes up for the shortness of the sun's trajectory by a great frequency of sunny days. Mountain air is of a light, keen, crisp and sunny complexion at all seasons, as compared with climatic areas in which the air is heavy, alternately relaxing and chilly, moist and sunless. Spring and late autumn need be avoided at low and middle altitudes only.

PART II

THE AIR AT ALTITUDES

PART II

CHAPTER I

The call of the heights—Alpine pedestrianism—Poverty or enrichment of blood—The case of domestic animals—The corpuscles in the human blood—Anæmic persons—Muscular effort and fatigue in reaching altitude—The joint play of physical and chemical law—Multiplication, subdivision and concentration of hæmoglobin—Balancing losses and gains—Dissociation in the blood of the air-contained gases—French experiments *in situ.*

To go to an altitude is not the same thing as living at an altitude. One lives at an altitude for health or for livelihood. One goes to an altitude for change of air, for relief from a regular occupation by exercise of a certain kind, and for mountaineering.

The fashion in mountaineering was set by men of intellect ; it is primarily a scholarly sport that sprang up in seats of learning among natural philosophers bent on satisfying their scientific curiosity.

The physicist who was first in obtaining European reputation as a mountaineer was Horace Bénédict de Saussure, whose ascent of Mont Blanc marked out mountaineering as a scientific occupation and brought the peaks of the Alps within the pale of descriptive literature and poetry.

The literature of travel and that of mountaineering are cognate. In the nineteenth century mountaineering bulks very largely in the world of books and periodicals.

Specialisation has since taken place. Mountaineers are now expert climbers, they produce guide books, maps, etc. The word "altitude" has acquired a precise meaning which it lacked before.

Now geologists write about natural rock formation at an altitude ; medical men about air, water, light and sanitation at an altitude ; sportsmen about snow, rock and ice as an arena for natural athletics ; physiologists about the behaviour of the human organs at an altitude ; chemists about the interaction of the gases of the air and those contained in the human blood at an altitude ; physicists about the composition and

qualifications of the atmosphere at an altitude ; botanists about plant life in the Alps.

Here another field opens. Mountaineering becomes strictly a sport when it is practised for its own sake. It may then be divided into summer and winter mountaineering. The latter is to all practical purposes an innovation upon the former.

In general characteristics, winter mountaineering is like summer mountaineering. Its specialisation is that, in winter, the conditions of sport on the high Alps are met with at lower altitudes and brought thereby within the reach of the unambitious multitude. A winter sportsman need not be an "Alpinist" ; such games as skating, tobogganing, running on ski and curling divert his attention from mountaineering for its own sake. The discomforts endured in the Alpine huts in summer are not associated with the winter sports. The pursuit of health by exercise under the most bracing conditions becomes as easy as it is pleasant.

The question, Why was winter mountaineering so late in coming ? may be answered by stating for what reasons winter mountaineering is essentially a modern sport.

Great prejudices had to be overcome. It was out of the question for health-seekers to go to the Alps in winter till altitude had been made accessible by the construction of mountain railways. These depended on the construction of large and substantially built hotels at the railway termini. It was unthinkable that townspeople would consent to move into the Alps till central heating had been devised to annihilate the element *cold* in every room and space. Now those conditions are fulfilled. Winter sports come in as a fresh luxury in the lives of those who are visitors to the Alps ; as a new and unexpected resource to those who dwell in the Alps for a livelihood or for the cure of disease. Winter sports are an elegant and health-giving adjunct to modern civilisation. By them, the characteristic of winter life for most people—confinement, is being removed. Anybody may now spend Christmas at an altitude twice as high as Snowdon or Ben Nevis with quite as much comfort as in London.

But some evils attend the overcrowding of Alpine resorts. People should be careful lest they annihilate the good effects of pure air, keen frost and all-day sun by converging upon some

fashionable spots and packing themselves together in unwholesome luxury, in open defiance of every consideration of health. Often they bring with them the germs of disease. All that altitude demands is a fair opportunity, and this it is not always granted.

The remedy is found in *pedestrianism*, on the principle: All day out of doors, all night in the air. But how is one to get about on one's feet in deep snow? The importation into the Alpine valleys of the ski used on the Norwegian flatlands came at the right moment to give in winter practically as much liberty in getting about as holiday-makers enjoy so much on the Swiss cattle-grazings and open uplands in summer. There could be no hygienic advantage for healthy people in repairing to the Alps if they found themselves deprived of out-of-door exercise by unpassable depths of snow.

The ski is the winter foot-gear of those who are content to potter about in the sun, as well as of those who wish to resume on the glaciers and amid the peaks the favourite sports of the summer season: climbing, snow-craft, ice-craft.

Experiments made in the course of balloon ascents throw light upon the vexed question of mountain sickness. So do the latest experiments made in the Mont Blanc and Monte Rosa observatories as to the modifications in the composition of the blood caused by exposure to high altitudes.

Does altitude impoverish or does it enrich the blood? The former theory used to be very generally advocated. Then it was claimed that the thinness of the air, combined with the toilsomeness of an ascent, *did* impoverish the blood and exhaust the system; but that later some organic reaction took place, and this reaction was appealed to to explain a double physiological phenomenon: First, that among mountain populations there is nothing to show greater poverty of blood than is forthcoming elsewhere under like hygienic conditions. Second, that plain-dwellers of an anæmic disposition, whatever might curatively happen to them while they were at an altitude, returned to their homes with enhanced vitality and with their blood restored to its normal condition, at least for a time.

The doctrine of the physiological and mental inferiority of mountain races has had its day, supported by superficial observa-

tion of such phenomena as mountain sickness, underfeeding and cretinism, in pre-scientific times. As a set-off, people whose interest it was to get good men have shown a marked preference for mountaineers. Mountain races have pretty nearly everywhere established their superiority as fighting races, particularly in the days when what was most appreciated in the soldier were the physical qualities : robustness, a fine appearance and bearing, endurance and cold-blooded courage. It would be idle to expect those qualities from ill-nourished and thin-blooded men. The Alpine races have supplied Europe with military elements which monarchs competed with each other to secure by every kind of financial and honorific bribery. For instance, from the middle of the sixteenth century to the eve of Waterloo, half the manhood of Switzerland was enrolled in armies operating in the flatlands and even beyond the seas.

But it is not only military opinion that brought a tribute of praise to the healthiness of mountain races. The poet, ever in search of human specimens as perfect as possible in which to embody his ideals of beauty, of wholesomeness of mind and body, generosity and heroism, has often shown that he has a preference for the mountaineer, whom he identifies with the freedom of outdoor life, the domestic virtues, boldness in self-sacrifice and political liberty.

All this affords a pretty complete negative proof that mountains and their climate offer as good opportunities as exist anywhere for the development of a fine breed of men. So now let us turn to the strict investigation of facts which contemporary science has entered upon and the results of which we may express here in plain and popular language, without embarrassing our style or perplexing our readers with many terms that may be thrown aside when one steps out of the laboratory and the specialist's library.

There is in all animal blood, whether human or belonging to the inferior grades of creation, a fundamental adaptability, and, in the means of blood nutrition, a fundamental variability which, in the end, meet all emergencies. According to altitude, adaptation and nutrition bring into operation a physiological mechanism in which the laws of physics and those of chemistry are closely associated.

If we first turn to the blood of animals, domesticated animals

such as follow man in his migrations or simply in his journeys from flatland to highland and *vice-versa*, we find in the blood of those animals an enlarged capacity for the absorption of oxygen at altitudes. Thus, to meet the heavier demand made upon their energy, for work or for expenditure during the process of growth and for duration, those animals possess resources with which they may dispense in so-called happier climes.

Our reader knows already that the rarity of air has its exact repercussion in the rarity of oxygen. This gas being the very breath of life in amounts that are immutably fixed, else death must ensue, some new physiological process becomes indispensable at an altitude, not only to store it in the blood in the same proportion as it is yielded by the air on the seaside, but even to fix in the blood the additional quantity wanted to meet the extra expenditure thrown upon living organisms going through the routine of labour and life in a thinner and colder air.

Some of the outer physical signs of adaptation we have already mentioned. With a view to putting to the test the rapidity of such adaptation when induced by deliberate act of man, some ordinary wild rabbits were set to breed among themselves at the altitude of 2,900 metres. After seven years they had somewhat dwindled in size, the ears were not so large, the coat was of a lighter colour and of extraordinary thickness—an evident approximation to the attributes of Arctic and high-Alp *fauna*.

With reference to physiology, that artificial race of mountain rabbits showed 70 milligrammes of metallic iron in suspension in the blood, as against 40 in the blood of their congeners bred in the flatland, and the oxygen in their blood was as 17 to 9 in the blood of the flatlanders. A few generations in a climate and altitude adapted to that effect, a process of seven years altogether, showed complete adaptation. It is easy to control this observation by bringing into its scope the sheep which spend the summer, from one end to the other of the Alpine range, at altitudes varying from 1,000 metres to about 3,000. Take a lamb born in the plain and remove him to the altitude of 2,500 metres for six weeks only. You will find metallic iron in the blood counting for 60 instead of 32, and oxygen counting for 17 instead of 7. The same applies to herds of cattle

wandering within the six months of each summer from low-lying meadows to grazings 6,000 feet higher, and back again. The adjustment of blood nutrition by oxygen takes place at each level, without either excess or insufficiency at any—which would show in bad health. Thus we may say that the process of blood nutrition is effected by the keeping of an ever mobile balance in which an impoverishment of the air is ever exactly neutralised by an enrichment of the blood. At heights at which the tension of oxygen begins to be reduced, blood begins to acquire a larger quantity of hæmoglobin, as is shown by the increase in solid substances and in iron. The blood thus shows for the absorption of oxygen a great faculty which counterbalances the rarity of the air. The enrichment of the blood makes it possible for the function of breathing to be attended at high altitudes with the same full results, when the tension of oxygen is weak, as at a level, when it is at a normal tension (or rather, a habitual, in the case of the person or animal concerned). Blood adaptation takes place within a very short time and, on this account, does not fall into the same category as adaptation to cold.

The physiological phenomenon which enables man and animals to tolerate a much rarified atmosphere may be accompanied by a considerably increased frequency in lung breathing, by an acceleration of the beats of the heart, bringing the blood more frequently back to the lungs; but research has shown that the most important agent in procuring the adaptation of the human organism to low barometric pressure may well be an increase in the number of red globules or corpuscles in the blood, that is, an extension and intensification in the respiratory activity of the blood.

The scientific counting up of globules at various altitudes shows the primary effect connected with residence at an altitude to consist in an accentuation of the normal process of blood making. Only in the case of prolonged residence should one consider such habituation to be primarily dependent on the amount or kind of food received through the digestive organs. Exposure to cold, keenness of air, exercise and labour do encourage the nutrition of the blood, but by stimulants of a totally different order, because the food that stills appetite

exercises no direct influence on the blood. Low pressure is by itself sufficient to call for, and to bring about, the increased oxygenation of the blood required to meet such low pressure and render it harmless to the healthy working of the human organism. Animals have been kept artificially for months in laboratories, under pressures brought down to any level to which man may be subjected. The examination of the blood in the course of such an experiment shows in its composition the same modifications as result from being exposed under natural conditions to a considerable lowering of atmospheric pressure. These degrees are quite calculable as one rises from one 1,000 feet to another above sea level.

Neither stimulants nor irritants externally applied to the body (such as salt air, etc.), neither great intensity of light, neither potent solar heat, neither the agitation of the atmosphere, neither the lowering of temperature, though sufficient to account for the vitalising of blood in the vessels nearest the skin, could account for the equal distribution throughout the arterial system of this new complexion of the blood.

The solid fact remains that after removing to an altitude of, say, 1,800 metres, people in ordinary health, or even somewhat anæmic—benefiting by altitude—may depend on finding in their blood, after a fortnight, an increase of 20 per cent. in the corpuscles, and of 7 per cent. in hæmoglobin. Should they further benefit by altitude, at the end of a month a like examination of the same person will show an increase to 23 and 15 per cent. respectively.

Is this increase merely a curious physiological fact, or may it be considered as of worth from a therapeutic point of view? There is little doubt as to this benefit in the case of anæmic persons making a stay at a moderate altitude. They are exposed to health conditions—in the matter of barometric pressure—in which the local and constant inhabitants give every proof of full-bloodedness. But when those anæmic subjects return to their original abode, do they lose the benefit of the reaction against reduced pressure on the blood, which has inordinately multiplied their blood corpuscles and hæmoglobin, or having been "screwed up" to a, with them, inordinate pitch, do they drop again to their original poverty in blood globules and deficiency in oxygenated elements?

Investigation shows the number of blood corpuscles in the case of born highlanders (and of temporary residents at an altitude returning home), to be reduced in the lowlands to the number and to the chemical activity that are consistent there with healthy and active life. Should they fall under the normal, this would not be an essential phenomenon, but rather one accruing from unsanitary environment or from some disproportion between a person's vitality and the calls to which it might be made subject.

The increase in globules, from the moment it has set in, may be rapid or slow. Almost sudden at first, it will sway to and fro as a sliding scale and reach its maximum some six months after removal to altitude, and will thereafter be found to sway between that maximum and a minimum which is practically the " norm " at the given altitude. Food, exercise, temperature bring about those slight modifications in blood nutrition, to the exclusion of the " glass." One may thin one's blood artificially, by an excess of cooling drinks, for instance, or one may hinder the formation of blood corpuscles by tiring out or starving one's system. The reaction of altitude upon the blood of consumptive patients has a tendency to exceed their strength at first and may betray this by a feverish condition. Consumptives produce erythrocytes by a reaction which is the more energetic in proportion as the bad ventilation of their lungs, owing to disease, makes the process more urgent in defence of life. Under-feeding, insanitary surroundings, will completely defeat at altitudes, as well as anywhere else, the health-giving reaction. That is why we must emphatically assert here how complete is the medical proof that unsanitary life conditions, the existence of which and exposure to which are always dependent on the will of man, must anywhere work havoc upon offenders with ruthless justice.

When villages in north Russia are completely cleared out by typhoid, it is because the inhabitants have thrown away, to their own destruction, the prophylaxy of cold and snow. As they will take no warning, the burning down of their hovels by official order, and compulsory abandonment of the site, ensue, or did ensue, on public grounds. In the valleys of the Alps the sacred right of the republican to be dirty brings about like results, unfortunately without the peremptory burning out of the offenders.

Inflammatory pneumonia, pleurisy and the like may be linked up with meteorological conditions, but, up there, for anything infectious, and even eruptive, including the local cases of consumption, man is alone responsible.

On persons conveyed to an altitude without any muscular effort on their part the mechanical effects attending the fall of the glass may be seen to advantage, that is free from the complications arising from organic fatigue. A horse, a railway carriage, and even a motor car are most comfortable vehicles in which to enjoy by stages that kind of adaptation to rarefied air which we have just called the mechanical. There is no doubt that the rarefaction of the air is then subjectively felt as a relief. Even when moving upwards on foot, people in a responsive mood experience a feeling of physical well-being and mental exhilaration. But if our organs are to profit by the feeling of elasticity in working arising from the removal of pressure, previous oxygenation must not have been defective, nor more demanded from the oxygenating elements than the mere business of blood making that is their occupation. For a difference in barometric pressure of 145 millimetres, equal approximately to a hypsometric difference of 1,300 metres, and starting from a low level, adaptation unaccompanied by muscular effort entails practically no strain whatever upon the organic life of the body. Automatic breathing becomes quicker and of greater amplitude, the chest moves more easily, the lungs are more deeply filled and more thoroughly ventilated. Under those conditions, the whole effect of the change in altitude is concentrated in the making of blood.

One sees, however, here how *muscular* effort under conditions requiring barometric adaptation may be a determining cause of mountain sickness. This manifests itself either *in ovo* or in its full compass, when warm-blooded creatures pass by means of muscular effort from an atmosphere where oxygen is abundant to another in which it is scarce.

Adaptation to altitude is in itself an exercise, and often a severe one. One should be sparing of voluntary effort till the adaptation is effected. People whom their mental constitution predisposes to sleeplessness and excitability

while the chemical process of adaptation affects their brain cells, might well lie down during the day, to escape from every occasion of fatigue that would mean cerebral excitement at night. They should also wend their way to the heights "on a rising glass," because they then meet—comparatively speaking—heavier air as they go up, and this would give them a few hours' grace.

Though full-grown red corpuscles are admittedly less numerous in the blood of women than in that of men, owing to the periodic rejuvenation to which women are subject, the comparative thinness of their blood is no longer apparent at an altitude, a sure indication that the cause of its enrichment is external.

It is plausible, as a matter of physics, that a lower pressure of oxygen in the organism should afford an opportunity for the development of blood corpuscles in numbers, reciprocal fluid compression being to some extent removed. It is also cogent, as a matter of reason, that the call for oxygenation arising from a scarcity of gaseous material per cubic volume in the internal economy of the human body should find satisfaction in a multiplication of hæmoglobin, not by a sort of magic, but simply by the exercise of powers which experience shows it is well within the endowment of our organism to put forth. This is simply a matter of range in vitality and one for the exercise of our inborn recuperative faculties. Our normal organs, when free from lesions, are provided with means of adaptation which are designed for all the latitudes and altitudes where man can find vegetable and animal sustenance. Beatings of the heart, breathing troubles, are temporary concomitants of adaptation when the individual thus affected is out of sorts. But gradual adaptation to his novel circumstances aims at providing him with *active* means of restoring his equilibrium.

Blood chemistry shows an effect of climate upon human physiology which is strictly altitudinal. Here the element *time* and the element *effort* may be totally eliminated from our thought, and that of *weather* too, for we are dealing with what we may term *physiological statics*. Our bodies being mixed liquids and solids are subject to physical laws. The active chemical processes of which we are the seat, the laboratory as it were, are not set free from static law because they belong

to that mysterious, spontaneous order that we call organic chemistry. As our blood must be completely saturated with oxygen, completely meaning the exact amount of saturation that corresponds to the normal blood heat and well-being of each individual, our system will strive after the normal degree of saturation on the top of Mont Blanc as well as on the Equator or within the Polar Circle. This degree is, as it were, absolute, and everything else revolves round it and is relevant to it. To that effect we are organically made aware of the smallest diminution or augmentation in oxygen. Such a diminution or augmentation, viewed in itself, is entirely confined to the sphere of physics and inorganic chemistry. Yet the slightest change either in pressure or composition of the air has its organic reflexes within our body, where a force elaborates life while moving within physical law in what refers to matter, and within chemical law in what refers to activity.

The multiplication of hæmoglobin is thus characteristically associated with deficiency in oxygen both within and without the body. An alteration in the physical state of the atmosphere entails a supplementary chemical activity within ourselves. When the degree of saturation of the blood is diminished by the physical factor, when the tension of oxygen within the body goes down, then the number of cells in the breathing tract of the lungs increases from moment to moment, and the manufacture, as it were, of fresh supplies of red blood corpuscles begins. We may, if we like, compare the activity of the cells to a kind of hunger, but this is purely a convenient analogy without any reality.

The effect of a scarcity in oxygen at an altitude may be better compared, in its hygienic results, to the old-fashioned habit of blood-letting, upon which it is a decided improvement, because it is quite free from artificiality. To rise to a moderate altitude is to regenerate one's blood. The old corpuscles are rapidly spent, the seat and means appointed for the formation of new corpuscles become active and produce them in abundance. Whatever be the mechanism whereby a diminution in the tension of the oxygen brought to our lungs is met—so as to pump in more—there is an immediate compensatory enrichment of the blood : erythrocytes in greater number,

multiplication of hæmoglobin, an oxygenating action of hæmoglobin upon the erythrocytes. The impregnation is thus complete, and the provision of oxygen required for what we may call the chemical respiration of the tissues is supplied.

The stimulation of cytogenesis is thus shown to be a function of altitude. The higher the place at which we analyse the blood, the more numerous and the more recent the globules. The more recent and the more numerous our blood corpuscles, the younger we are in the light of organic chemistry! All of us who have ears for the call of nature will seek to experience in our persons rejuvenation by removing our bodies to a suitable altitude. When we do this, what we are essentially doing is to seek under sanitary conditions a reduced atmospheric pressure to start afresh our internal chemistry. If we go too high this chemistry will not be able to work under a pressure which has gradually become too slight: we shall be physiologically "stuck." If we expose ourselves to too much cold, or to cold for too long a time, we shall paralyse, as it were, our young and new blood. If we underfeed ourselves we shall fail to provide our internal laboratory with the fuel required to keep the shop warm.

But, of course, *rien de trop*. There may be too much of a good thing, a scarcity of oxygen is destructive of life, as much as a moist tropical heat or a torpor-producing exposure.

Provisionally the following conclusions may sum up the subject:—

In an ordinary animal placed under reduced barometric pressure, say, at an altitude of 3,000 feet, the blood globules "in stock" are rapidly sucked out and then perish. The strain put upon them is too great. Their helpless little corpses are swept away. They pass into pigment, or are washed away into the bile secretion. A compensatory process of blood production sets in immediately in the marrow of the bones, in the spleen and liver, in the blood itself. The occasion of the process is physical; its results are chemical.

Microcytes begin to teem. They pass into hæmoglobin; hæmoglobin combines with hæmatin; thus oxygen and iron are fixed: then the balance between the outer atmosphere and the nutrition of the circulatory elements of the body is chemically restored. This is, after all, the usual course of hæmatosis under any conditions, only more of it.

On returning to flatlands, or, generally speaking, on any lowering of the altitude, the blood corpuscles impregnated with oxygen in excess of what is wanted at that altitude, are not replaced when used up. The cycle is thus completed.

Persons whom the ordinary oxygenic supply at their altitude fails, from whatever cause it may be, to maintain in good health, should live at the altitude at which they have found this insufficiency to disappear. If they must return to their ordinary station, having secured at a higher altitude normal conditions for a sufficient oxygenation of their blood, they will find that they will not drop back into their former unhealthy condition, provided their hygiene and the character of their occupation do not actually thwart the cure.

A universally applicable rule appears from this explanation : the excitability of our blood-producing agencies is what the hygienist should aim at retaining or restoring above all things, and of course by natural means. A change in latitude can do but little in that respect. It is only a good general tonic. On the contrary, a rise in altitude commensurate with the health conditions of every individual will provide at once the stimulant wanted to bring into play the excitability on which depends the renewal, the amount and quality of arterial blood.

Now is the time and place for a few words about the composition of the air out of which our lungs pump the food which they receive for the blood. The mechanical mixture—not chemical combination—of gases composing the breath we *inspire* contains, out of one hundred parts, twenty parts of oxygen, the blood food ; seventy-nine parts of nitrogen, which for maintaining life is a negative element ; and the remainder, a mere fraction, contains some carbon dioxide (or some carbonic acid), which may be destructive of life.

The breath we *expire* shows air modifications as follows : the amount of oxygen returned to the atmosphere is reduced to 15 per cent., while the liberated carbon dioxide gas has risen to 4 per cent. The decrease in the former and the increase in the latter are co-related.

What interests us are the effects brought about by changes of altitude in the quantity of oxygen absorbed into the blood through the lungs, and the accumulation of carbon dioxide in

the circulatory system, health being directly concerned in both items. The general proposition is that the presence of an undue quantity of carbon dioxide in the blood is injurious.

Three sets of experiments we shall quote to gain enlightenment upon this—one from France, one from Switzerland, one from English sources. Our readers should carefully note that these experiments take us beyond the zone of health-giving altitudes, for Europeans at least. We have already seen that for us the "altitude of happiness" barely exceeds 6,000 to 8,000 feet, approximately the altitude of Simla. The critical point in altitude is that at which the carbonic acid resulting from the combustion of oxygen is greater than the quantity which can be expelled through the lungs in the ordinary way.

Comparative measurements of the quantities of oxygen and of carbonic acid contained respectively in arterial and venous blood, at Paris, Chamonix and the top of Mont Blanc, measurements due to Messrs. Raoul Bayeux and Paul Chevallier (1913), were reported upon to the Academy of Sciences in Paris, on March 30th, 1914, in the following terms :—

"In order to ascertain the action of high altitudes upon the quantity of oxygen and of carbonic acid contained in the blood of animals, we began experiments in the Faculty of Medicine, Paris. We continued those experiments at Chamonix, in the laboratory constructed by Monsieur Vallot, and on Mont Blanc itself, in the Observatoire Les Bosses (altitude, 4,362 metres).

"The researches made in Paris extended over two months ; those at Chamonix over one month, and these were continued for nine days at Les Bosses."

The experiments were made by the investigators on their own persons and on rabbits, which, in the case of the Chamonix and Mont Blanc experiments, came from the valley of the Arve at Sallanches (altitude, 546 metres). These rabbits weighed more than the Paris rabbits. Moreover, the Paris rabbits were enclosed in badly-ventilated and badly-lit quarters (conditions approximating those which produce anæmia). The Chamonix rabbits were kept in the open. At Paris and at Chamonix the food consisted of green stuffs and of bran. At Les Bosses they were fed on oats and carrots.

"In order to measure and weigh the blood gases the apparatus of Haldane and Barcroft was what we used. As our readers already know, this sets free the oxygen by means of ferricyanide of potassium and the carbon dioxide by means of tartaric acid. In spite of some possible errors, this apparatus gives results sufficiently accurate for purposes of comparison. One may operate with it upon volumes of blood of one cubic centimetre.

"When operating upon ourselves, we drew the blood from a vein in the sinus of the elbow. When operating upon rabbits, we examined blood drawn from the arteries simultaneously with blood drawn from the veins, in order to establish a proportion between the gases contained in each.

"The tables which we give below show the results which we obtained in performing those various operations. The figures show the percentages for both gases per 100 cubic centimetres of blood.

"The effects of high altitude were somewhat different in the case of each of us. Dr. Bayeux, though he was not afflicted with mountain sickness, showed cyanosis, some irregularity in breathing and intestinal troubles. Monsieur Chevallier suffered from mountain sickness the first two days (headache, want of appetite and general nausea without vomiting).

"In the first instance, concerning the set of experiments which we carried out upon rabbits and upon ourselves, experiments with which we are now going on in Paris, with a view to completing them next summer at Chamonix and on Mont Blanc, we may now safely declare, with respect to venous blood and arterial blood alike, that oxygen and carbonic acid, at each of the three altitudes under consideration (40 metres at Paris, 1,041 metres at Chamonix, on Mont Blanc as above), undergo general variations as follows: oxygen is in larger quantity in the blood examined at Chamonix than in that examined at Paris; the quantity varies but little as between Chamonix and Mont Blanc. As for carbonic gas, that too increases as from Paris to Chamonix, and it continues to increase to a very noteworthy extent as between Chamonix and Mont Blanc.

"On the other hand, the tests which we made on rabbits at

Chamonix and on Mont Blanc (taking rabbits of like origin) yielded the following figures :—

"Table 1.

Rabbits from Sallanches, Mont Blanc blood test only.

Averages.

Arteries.		Veins.	
Oxygen . .	14·03	Oxygen . .	9·70
Carbon dioxide .	52·08	Carbon dioxide .	69·35

"Table 2.

Rabbits, blood test at Chamonix, then on Mont Blanc.

Chamonix.

Arteries.		Veins.	
Oxygen . .	13·00	Oxygen . .	11·30
Carbon dioxide .	41·50	Carbon dioxide .	48·60

Mont Blanc.

Oxygen . .	14·10	Oxygen . .	11·10
Carbon dioxide .	60·26	Carbon dioxide .	79·66."

From those results the observers considered they might draw the following conclusions :—

1. High altitude determines a variation in the quantity of oxygen and carbon dioxide contained in the blood.

2. The increase in carbon dioxide is more considerable than that of oxygen.

3. One of the investigators having submitted to special tests while suffering from mountain sickness, it would appear that, while in that condition, there was no palpable increase in the quantity of carbon dioxide, but a considerable reduction was observed in the quantity of oxygen contained in venous blood.

The learned authors of those investigations add that their experiments coincide with the results obtained by Messrs. Tissot and Hallion, in 1901, who tested the increase of oxygen and carbon dioxide in the blood of a dog, which they conveyed to high altitudes by means of a balloon and examined there. But those French ezperiments on Mont Blanc are not quite borne out by those of the Barcroft party on Monte Rosa, which will be recorded further on. Balloon tests of human blood were attempted in 1902 by Dr. Justus Gaule.

Before entering upon an account of the experiments recorded in the next pages, the uninitiated will excuse our reminding them that venous blood normally contains 8 to 12 per cent. less oxygen and 6 per cent. more carbon dioxide than is contained in arterial blood. An ordinary adult individual draws at each breath into his lungs 500 cubic centimetres of air. The lungs absorb from 4 to 6 per cent. of the oxygen and restore to the outer air, in place of this oxygen, from 3 to 5 per cent. only in carbon dioxide. Thus, gases "expired" are not quite so voluminous as the gases "inspired." The quantity of carbon dioxide returned to the atmosphere is independent of the quantity of oxygen that is absorbed.

The quantity of carbon dioxide that is eliminated is in direct proportion to the elevation of temperature, but inversely proportionate to barometric pressure. The quantity of "inspired" carbon dioxide diminishes by as much as the temperature is lowered; it increases by as much as the pressure is reduced. A rise in temperature and a lowering in pressure combine their effects and bring to a maximum of intensity the elimination of carbon dioxide from the lungs. The quantity of "inspired" oxygen is reduced in proportion as the external air undergoes dilatation through heat.

We have already seen how the weight of air—and consequently the weight of gas therein contained—is reduced in any given volume by altitude. But let us explain again that air may be considered as to volume and as to weight. If we consider volume, oxygen counts for 20·93; nitrogen for 79·07, and carbon dioxide has no appreciable volume. If we reckon by weight, oxygen comes out at 23·13; nitrogen at 76·87; carbon dioxide at from 4 to 6 ten-thousandths (from three to seven grammes per cubic metre).

CHAPTER II

Two balloon experiments—Reflections on the data accruing therefrom—The views of a professional balloonist—At what height does blood become asphyxic?—The humours of research work in the car of a balloon—Mountain sickness an attendant of exertion rather than of altitude.

The balloon experiments of which we now wish to give an account were undertaken in the summer and autumn, 1902, by Professor J. Gaule, of the University of Zurich, with that town as a starting point. His first intention, in rising in the air, was not to observe the action of altitude upon the blood but to study mountain sickness. The geologist Heim, his colleague, had risen in the balloon "Vega" to an altitude of 6,000 metres. His report as to his sensations gave Professor Gaule ground for supposing that one's *malaise* in a balloon at high altitudes and mountain sickness were one and the same thing. Judging from Professor Heim's experiences, it was allowable to suppose that it was not in fatigue that mountain sickness originated, but that it was a state of distress superadded to general physiological conditions, the actual and primary cause of which would be purely and simply altitude.

Having allowed the particular point of mountain sickness to go out of sight, the more general question arose how suitable experiments could be made to show the modifications which the composition of the blood undergoes at certain altitudes. Mountain sickness might well be but a symptom of such modifications. Then arose another incidental question, or rather, this time, the essential point of the inquiry to be instituted: Was the multiplication of blood corpuscles which had been observed in the Andes, and, for instance, nearer home, at Davos and Arosa, another symptom (accompaniment) of such modifications? Perhaps these modifications would not take place with sufficient suddenness during a balloon ascent to bring them within the reach of observation. As mountain sickness *is* a process that is actually observable from its inception to its termination, it would follow, if modifications in the

blood could not be observed during the same period, that the occurrence of mountain sickness has nothing in common with blood starvation. If, on the other hand, such modifications are detected, we have to face the hypothesis of very thorough blood modifications at altitudes, and it becomes imperative to acquire a knowledge of every single element or factor at work in the process. The blood becomes the object of observation.

To begin with, it would not be advisable to restrict oneself to the counting of blood corpuscles. That was, indeed, a most important factor, but one must extend the scope of reckoning to as many factors as possible. In any case the time must be short, so as to be sure of bringing within the field of observation only genuine alterations taking place in the organism when exposed to altitude. Professor Gaule writes :—

"My wife offered to accompany me, in the absence of my assistant. She was well versed in the methods which would have to be applied during the ascent and had often been employed by me in counting blood corpuscles. Before starting we ascertained the number of our blood corpuscles, the amount of hæmoglobin, the specific weight of our blood, we prepared our microscope and its material and the rabbits that were to come with us."

We must not omit to say here that the balloon in which both ascents were made was that of Captain Spelterini, whom balloon flights in all parts of the world where lighting-gas can be got, except India and some regions of the Far East, have justly made famous. Captain Spelterini generously offered to spare some of his own blood, in addition to that of Herr and Frau Gaule, for the experiments, besides, of course, undertaking the full responsibility of piloting his balloon.

The aircraft was launched into space at mid-day on the 11th of August, 1902. Its occupiers arranged themselves on the floor of the car to carry out the intended experiments. These were begun at two o'clock, after the "victims" had been two hours in the air—the time is important—and had reached an altitude of 4,000 metres, approximately, the same as that at which the above-mentioned French experiments of last year on Mont Blanc were carried out. Professor Gaule placed a board on his knee, they sat on bags of ballast and on the cases in which the rabbits were stowed away. The operators began by determining

the specific weight of the drops of blood which they drew from their finger tips. The whole party felt in the pink of condition. The sun shone brightly and gave so much heat that Captain Spelterini was much occupied in screening the scientific couple from its rays.

After the determining of the specific weight of the extracted blood came the turn of the hæmoglobin. It was then discovered with some astonishment that the quantity of hæmoglobin held in the blood had diminished. Now, at that altitude, the oxygen pressure was reduced by two-fifths, and yet the hæmoglobin—the agent in the blood, the "busy bee," whose business it was to fetch, as it were, the atmospheric oxygen in order to convey it to the tissues—was present in smaller quantities, however much the supply of oxygen had become rarer in the external air, and demanded extra labour for its collection.

Still, the investigators did not experience the slightest difficulty in breathing. The means of blood oxidation seemed to be forthcoming to an extent quite sufficient to maintain the organism in ordinary working order. There was no noticeable acceleration or deepening of the breath. This might have been different if any real strain had been laid upon the system, but the mental work connected with research was actually as easily accomplished as in the laboratory at home.

When the deficiency in hæmoglobin had been ascertained, the counting of the corpuscles in the extracted blood showed very large figures indeed, and this in the blood of all three. The number of blood corpuscles had gone up while the quantity of hæmoglobin had gone down. It was apparent that the blood corpuscles no longer contained so much hæmoglobin as below: they had undergone a change. As for their number, it had gone up enormously in the short time, by about 40 per cent. as compared with the enumeration made at nine o'clock in the morning.

The second ascent took place in October, same year.

On the 13th Captain Spelterini informed Professor Gaule that on the next day he would have another opportunity of renewing his investigations. This time, however, as a fellow traveller was already booked for the expedition, the Professor had to leave his wife below. Three passengers again would be

sufficient weight for the balloon, if it was to convey them to an altitude superior to 4,000 metres. On the preceding occasion the balloon had risen to 5,300 metres. This time Dr. Gaule did not take up any animals with him, intending to confine his attention entirely to modifications of the blood while suspended in the air. He therefore set out with a more elaborate apparatus, so that he might carry out microscopic blood observations at the same altitude at which the blood would be drawn.

Before starting he made some dry preparations of his own blood, which were set aside for comparison after his return with the preparations yet to be made in the balloon. With a view to determining the contents of his blood in iron, he put away a small portion in a hermetically closed glass vessel, also with a view to comparison with that which he would draw from himself in mid-air. As before, he counted his blood corpuscles in the morning hours and ascertained the quantity of hæmoglobin. At 11.30 on the 14th of October he hurried to the barrack ground and the start was made at 12 o'clock mid-day.

In the middle of October the winter conditions of weather may already make themselves felt over Zurich in the appearing of the usual layer of stationary clouds. On that day these hid every part of the sky. At an altitude of between 1,000 and 1,200 metres the balloon broke through the bank of mist and fog and rose into clear air, a flawless sky and floods of sunshine. The passengers were prepared for severe cold. But, as frequently happens even in mid-winter, thanks to windlessness and reverberation from the fog, the thermometer marked plus 20 degrees in the sun and plus 6 in the shade. The white peaks of the Alps, surging from the mist, the sea of mist itself, the seclusion from the world, brought about by the intervening layer of clouds, made upon us, says the Professor, a peculiar impression while swinging in mid-air.

But it was not the time in which to indulge in poetic impressions. At the altitude of 3,000 metres he drew "first blood." An hour had passed since the ascent had begun. After preparing this specimen for microscopic observation the specific weight of his and Spelterini's blood had to be ascertained, then the determining of the amount of hæmoglobin, and then the counting of the corpuscles, when the altitude of 4,200 metres had been reached.

The Professor held the microscope on his knees and counted. His companions in turns wrote down the figures at his dictation. Then came the making of a second set of microscopic blood preparations, this time above the altitude of 4,200 metres, and when four hours had elapsed since they had left the ground.

In the evening the party descended through the mist again, and then found they had drifted over the lake of Constance. Still suspended in the air, they were towed to shore by fishermen. The next day, in the laboratory, began the comparative examination of iron and hæmoglobin, of specific weights, of blood corpuscle totals ; and fresh drawings of blood, that the after-effects of altitude might be verified.

Assuming that the apparatus, blood census and other means of investigation gave reliable results, we may now inquire what variations in blood composition are borne out by the data collected during those two expeditions. The enormous increase in the number of corpuscles, even after a two hours' stay only at an altitude of over 3,000 metres, is the fact that dominates the situation. To explain this, one might suggest that the blood had undergone concentration. This would be quite possible. At an altitude, and particularly on that occasion, the circumstances would favour evaporation; but no appreciable change in the specific weight of the blood could be detected when comparing the three weighings—before, during and after—so this hypothesis has to be abandoned.

The multiplication of the corpuscles conceivably might have taken place only in the peripheric blood vessels, whence they were extracted. But, even if this were the case, the reduction in the amount of hæmoglobin in those exterior vessels, as a fact assumed to be limited to them alone, would remain to be accounted for.

As the quantity of hæmoglobin did not remain what it was, while the number of corpuscles increased, this necessarily shows that a difference in the chemical function of the blood attended the exposure to altitude. Besides, the blood corpuscles examined through the microscope during the ascent presented to the eye a shape different from that which was theirs before, and to which they returned after. Where did these

come from? The blood being a circulating medium, the seat of the multiplication of corpuscles remained in doubt. In presence of the generally prevalent view that blood corpuscles are generated in the marrow of our bones, it did not seem possible that these could suffice to produce so suddenly such an enormous supply of corpuscles. If we are to look at this problem with the eyes of Dr. Gaule, we should have to assume that new formations of blood corpuscles may take place in other centres than marrow, and that they may do so with extreme velocity throughout the circulatory system.

It seems pretty clear that extreme shortness of time, deficiency in hæmoglobin, multiplication of young corpuscles, and altitude must be viewed as a nexus. Remove from one's elevation to an altitude the momentaneousness which dominates the physiological situation in a balloon ascent, in other words, give time, then the scarcity of hæmoglobin disappears and is replaced, on the contrary, by an increase as compared with the low-level norm. It takes more time to bring about at an altitude the correlative increase in hæmoglobin (for the supply of which every provision is made by the unaided forces of nature) than a quick balloon ascent puts at the disposal of passengers. The production of young corpuscles exceeds the hæmoglobin supply, till the young corpuscles are themselves able to contribute to its production. There is a functional break in the manufacture of hæmoglobin during which corpuscles are "coined." But, once more, where is the mint—the seat of coinage? Perhaps a process which is hampered in the atmospheric depths operates more freely at a correlative altitude. Perhaps a subdivision, a breaking up of the globules takes place as a generative process throughout the course of the blood.

In any case, this new coinage cannot proceed simply from the ordinary course of oxygenation through the lungs. The first effect of altitude upon this part of the business is to embarrass, however much the second and more permanent effect of moderate altitude may be to stimulate, blood formation. While the salutary effect of this secondary degree in the process is beyond question, the effect of the primary degree must be allowed for while it lasts.

What is that primary stage which, when prolonged or attended with complications—such as fatigue and strain upon

the breathing apparatus—turns to mountain sickness ? Does the reduction of oxygen pressure bring on the mischief ? What removes it ? Does altitude, through its correlative changes in the composition of the air, become an active force ? Has it power to call some physiological force into greater activity, to endow with greater freedom some recuperative force that is checked here below ? The confusion is great, because the notion of altitude is double. On the one hand, the relation of the human body to the atmosphere is mechanical. On the other hand, the human body is a laboratory whose relation to the gases of the air is chemical. A more or less complete pneumatic *vacuum* would be a near analogy to mechanical altitude. In nature some chemical vacuum accompanies loss of pressure, and this seems to be compatible with causes of health.

It would perhaps be idle to look upon balloon ascents as a sort of therapeutic resource to bring about the pullulation of blood corpuscles desirable in anæmic persons. Yet sudden transference to a high altitude shows with what rapidity the human organism answers the helm, as it were, how promptly and amply it adapts itself when its faculties for adaptation are let alone to work out salvation. Balloon ascents are an experiment of great scientific value. They show how rapidly the organism is able to build up cells. In this experiment appears clearly how cell formation and cell division—segmentation—takes place under the influence of forces which we partly know already, and which for the remainder we are endeavouring to find out. That the cells, which we see pullulating almost under our eyes aided by the microscope, proceed from *nuclei*, whose origin brings us very near spontaneous generation, seems an assured fact. Are these *nuclei* form or substance ? Are they matter or force ? We know how some crystallographic formations arise " in no time " when there is saturation and some stimulus is applied to the solution. Is our case a parallel one ? We shall perhaps never know what it exactly is, as the abyss gapes as wide between organic and inorganic chemistry as it does between mind and matter, or, if you like, between male and female elements of fecundity at the point of generation.

Our own philosophising has led us some distance from the strict tenour of Dr. Gaule's experiments. Since we wrote, an

interesting interview with his skipper, Captain Spelterini, enables us to throw a few side-lights upon the picture. As it happens, there appeared in the *Strand Magazine* (April, 1914) one of those numerous sketches of his "flighty" career in which high spirits show themselves so closely allied with high altitude. Being a native of St. Gall, you might expect him to be more immersed in lace and *lingerie* suited to the airiness of modern woman's toilette than devoted to exploration in the domains of Icarus. He might have been a mountaineer, being a Swiss, but though he has ten times traversed the Alps, you would in vain look for hobnails on his boots. His ascents numbering 560 by this time, and having ranged up to 7,000 metres above the sea, he is a perfect storehouse of funny stories on the connection of health with altitude. With reference to mountain sickness, he will tell you that this does not exist for him and his clients, as, according to him, mountain sickness is inseparable from the effects of effort and fatigue upon the human laboratory. He has never become aware of it in persons whose condition of health when they entered his car was the habitual condition of any of us. He does not include among such the too numerous gentlemen and others hurrying upon the scene of departure, not only with their pockets full of a bottled supply of spirituous drinks for emergencies—which would be rather much indeed—but with a lot of that useful stuff already coursing through their blood.

But the aeronaut will tell you just as frankly that the other extreme too may be injurious, at any rate at an altitude of 20,000 to 25,000 feet. The balloon is then no place for the teetotaler. Those who are then teetotalers only on the spur of the moment fare badly enough. But the direst severities of altitude are reserved for the well-principled man whose objections to drink under those exceptional circumstances are a part of his immutable moral conception of the universe.

Captain Spelterini's well-considered doctrine is that, at unearthly heights, champagne is the proper liquid. Some 2,500 passengers from all climes, of all temperaments and ages, having come within the field of his experience, it is quite fair that we should be inclined to believe him. Having witnessed many attempts at substituting inhalation from oxygen bags for gentle alcoholic stimulation, he has entirely ceased to

recommend the former mode of relief, as it is difficult to dose it properly up there—just as difficult as champagne on the floor of this world—besides being far less pleasant in itself. The passenger is apt to take too much oxygen, or too little, and this brings about irregularities in the functions of the pulmonary and circulatory systems. Those symptoms of functional disturbance are those which accompany mountain sickness and show that this ailment too may be brought on by indiscretion in food and drink.

What is called for is not artificial oxygenation, but that a regular and sufficient propelling action of the heart should be quietly kept up. The timely administration of alcohol in moderate quantities and at proper intervals keeps up the circulation without interference with the breathing. A balloon ascent is a rest cure in which the gradual weakening of the action of the heart seems to be the risk attending extraordinary altitude. This slow approximation of heart pulsations to nought is quite disconnected from mountain sickness. It partakes of the nature of a collapse without the accompaniment of uncomfortable sensations, spasmodic lung action or vomitings. On the other hand, it is evident that an excess of alcohol and overdoses of oxygen must disturb the system equally. Spelterini has noticed that when his passengers turned pale and showed signs of imminent fainting, then was the time for uncorking the champagne, and that those who preferred the other remedy, or no remedy, were afflicted, in the case of the former, with acute, painful distress, while, in the case of the latter, life seemed to grow more and more negative. He would willingly conduct a systematic series of experiments, such as those he made with Dr. Gaule, to test the value of balloon ascents in air therapeutics.

We would not suggest that something similar to the mountain air rest-cure for the anæmic can be obtained from repeated and graduated balloon ascents. Some conclusions, however, may so far be safely drawn, as follows, from Captain Spelterini's vast and varied experience :—

1. That mountain sickness is not *the* normal accompaniment of elevation to an altitude.

2. That elevation to an altitude is not contrary to the continued operativeness of any natural function of our system on normal lines.

3. That a general slackening or exhausting of those functions, with consequent vital debilitation, supervenes gradually when elevation is exaggerated.

4. This functional—not organic—debilitation has then to be met by means of a stimulant such as will not interfere with the gradual habituation of the system to the circumambient air conditions while restoring its organic functions to their activity. Such a stimulant must be generally—not locally—invigorating. If locally applied, it disturbs the economy instead of assisting it. Its distribution throughout the system must be left to the system, which may be trusted to assimilate it through the normal distributive channels. Food is too slow, gas is too much of a specific. What meets the requirements of the situation is a liquid ingestion of light alcohol in effervescence.

5. The circulation of the blood in the peripheric vascular system shows some turgescence and higher colour in the cutaneous extremities. It is when the expansion of the small capillary vessels is interfered with by the weakening of the action of the heart—the sign of which is pallor, drowsiness, indifference to the sound of the human voice, insensibility to touch, that the stimulant should be administered. Its effect will only be temporary and no more is wanted to meet a temporary situation.

That aviators flying at high altitudes should be recommended the use of oxygen, and should be forbidden that of alcohol, does not disprove the soundness of Spelterini's practice. Aviators do not fall victims to mountain sickness as a matter of course any more than balloonists do, though the former are conveyed through the air at great speed. The air in which the balloonist has, as it were, his being is motionless as related to himself. To use a suggestive simile, the aviator is in the position of an engine driver, while the balloonist is in the situation of a railway passenger as related to the coach in which he sits, in which he is surrounded by air which is motionless with regard to himself, the only independent motion of a balloon being either upward or downward. The engine driver is not allowed alcohol, and the passenger does not think of oxygen.

To sum up, the net result of such balloon ascents—which are as going for an "outing" or an airing—is that the

circulatory blood goes through the process of pullulation, free from the intervention of any exertion, the latter being a characteristic co-efficient of mountain sickness. Whether the pullulation of blood corpuscles purposely brought about in that way may rank higher, as a curative appliance, than frequent drives in the country, is a small problem, the solution of which we are content to leave to our readers, if they care to see what they can make of it.

We should insert here the purport of a note received from Dr. Raoul Bayeux, one of the two Mont Blanc experimenters mentioned in the aforegoing chapter. What he writes comes in for quotation here because, while Captain Spelterini and his passengers experienced no distress at the altitude of 4,000 metres and even higher, the case seems to have been widely different when Dr. Bayeux and his friend subjected themselves to the same altitude on the icy and snowy slopes of Mont Blanc. He writes :—

1. The figures which I obtained as between Paris and Chamonix show that, at Chamonix, oxygen and carbon dioxide increase in the blood, and this I attribute to the more complete aeration of the lungs at this very moderate altitude (1,000 metres).

2. Near the top of Mont Blanc (that is above 4,200 metres), a still greater quantity of oxygen is shown and the quantity of carbon dioxide increases too, but the latter increases so excessively that a point is reached when the blood becomes asphyxic (unfit for the purpose of maintaining life).

Dr. Bayeux realises, as we do, that this declaration runs counter to the doctrine of the late Professor Mosso, of Turin. The observations of this scholar—published in 1897—connecting *mal de montagne* with a *deficiency* in *carbon dioxide* in the blood seem to have been made on one dog only, says Dr. Bayeux, while he and Dr. Chevallier operated upon themselves and upon twelve rabbits. Such discrepancies have, so far, only a documentary value, as we believe Professor Mosso would have rewritten his book had he not been debarred from this opportunity by the premature termination of his labours. We shall soon see what light is thrown upon this question by the English experiments that were conducted on Monte Rosa a few years after Dr.

Gaule's balloon experiments and two years before Dr. Bayeux's, which are to be continued, let us hope.

But though Mosso was evidently in error when he attributed *mal de montagne* to an atmospheric *deficiency* in *carbon dioxide*, we should like to know whether Dr. Bayeux, or his colleague, was in a state of *mal de montagne* when the blood was taken which showed carbon dioxide in asphyxiating proportions, because *mal de montagne* is a pathological state of the system, pointing either to an organic disability of the heart to propel the blood or to a temporary derangement in the nerves, *glands* and viscera, interfering with their function.

We are quite prepared to admit that in some individuals the organs may be so delicate, filed down, as it were, to such nicety, that they cannot recover from a change of pressure till restored to a stronger pressure. We know also that we may distinguish between oxygen rarefaction and carbon dioxide rarefaction. But *mal de montagne* is practically unknown among members of the Swiss Alpine Club. These folk walk and climb regularly, their hearts are ever in training. On the other hand, how serious may be the consequences of removal of pressure appears from the experience of deep sea research men, such as the Prince of Monaco, who bring up fish from the abysses of the ocean. On passing from the liquid element to the aërial, their eyes are seen to have jumped out of their sockets, their bladders hang out of their mouths, the scales fly off and their blood vessels are sprung. These are indeed organic disturbances of some gravity.

We have just spoken of rabbits. Before we proceed to further scientific talk, we may just as well elucidate this rabbit question—and some other questions concerning the behaviour of professors in balloons.

Captain Spelterini's very first ascent with Dr. Gaule is not unconnected with the dog of Mosso. Dr. Gaule intended to find out whether the proportionate decrease in carbon dioxide alleged by Mosso could be verified by testing for lactic acid in the muscular tissues of rabbits exposed to altitudes. We believe that on this occasion the attention of pilot and passengers was so much taken up with the scientific research work going on in the depths of the car that the balloon came within

an inch of colliding with the Urirothstock that towers above the lake of Lucerne. A rabbit had been pinned down upon the usual experimental board, while the others were waiting in the cases. The rabbit that was pinned down had its mouth stuffed with a handkerchief, dipped in chloroform, and was supposed to be as dead as Queen Anne. When the party had negotiated the Urirothstock, it became necessary to land on the nearest available patch of grass, as night was closing in. In manœuvring so as to land the captain happened to strike the rabbit's rack somewhat roughly. The pins flew out of their holes and out jumped the rabbit—supposed to be dead long ago—from the car on to the patch of grass. The professor immediately tumbled out of the car and gave chase. The runaway escaped, cheating the vivisectionist out of the oxygen, carbon dioxide and all the lactic acid that might have accumulated in his muscular system. It was dark by the time the balloon was packed, when the professor, map in hand, pointed out imperiously the bee-line to Beckenried, on the banks of Lake Lucerne. "You had better come with me," said Spelterini, "and take the road." The professor had one shoe on and one slipper, the partner of each having been aimed at the flying rabbit. He, nevertheless, stuck to his pathless bee-line, reaching Beckenried at midnight, wet, mud-covered, and with torn nether garments. After undergoing a thorough washing at the village pump he was put to bed and the lacerated garment given to the local tailor, who promised to return it by the breakfast hour. But the wakeful professor was stirring at dawn and appropriated without a thought the sleeping captain's trousering which had taken the place of his on the hook. We shall draw a veil over the quandary of the captain when it was his turn to don clothes that might not bring back to his cheeks the blush of dawn.

The captain was, indeed, much to be commiserated. Three times during the ascent the professor had made five neat holes in his fingers to draw his blood. He had almost been made to run into a mountain, and now he could not decently leave his room. He had narrowly escaped having to ascend in a car infested with experimental rats. Mice he would accept, and caged birds, and rabbits at a pinch, but rats that would nip his fingers without even the intervention of the authorised

operator's lancet, that he would not brook. He had been left to carry his balloon alone, as though it were the merest india-rubber bath in its case, and now his trousers were gone. He would avenge himself and tell the story and relate, too, how he once brought down from the upper stretches of the atmosphere a huge canister full of rarefied air, and how he conveyed it by train, holding it like a baby in his extended arms, and with what care he handed it to the professor, who came to the station to receive the precious burden, and how the clumsy professor allowed himself to be jostled by a nimble porter, and how the canister flew from between his hands, and how its contents were spilt in the circumambient atmosphere that was quite at the wrong pressure.

The captain will tell you that his objection to professors does not extend to sailors. He does not mind being their laughing-stock because he himself behaves abominably upon the sea, being, strange to say, a chronic victim to *mal de mer*. Even the ingestion of champagne will not help him then. The railway, too, is Spelterini's aversion. The merest waft of air from an open window will give him a cold in the head, wherefore he hates English company on his journeys. Get him down in a comfortable armchair, before a big fire, and he will tell you that in his balloon car draughts are unknown, and how balloon ascents, with carefully dosed injections of good red blood in between—scientific men, please do not read : oxygen—would, if only physicians had enough faith, be the means of raising the temperature of the most hopeless anæmic to the 42° C. of heat, characteristic of birds well provided with plenty of light marrow bones to produce blood pullulation. But who, in mid-air, will allow himself to be tapped for the sake of an ailing brother?

The real dilemma seems to be this: If one is raised without any physical (muscular) effort to a very considerable height, the risk to be run is that of passive collapse; if one walks, the exercise brings into activity the means of recuperation, but may superinduce *mal de montagne* through fatigue.

The "super-position" of mountain sickness to exercise seems to be the normal feature at heights approaching 15,000 feet. This appears to be placed beyond doubt by the

physiological observations made on Pike's Peak, Colorado (altitude 14,109 feet), in 1911, by Messrs. C. Gordon Douglas, J. S. Haldane, Yandell Henderson, and E. C. Schneider, the eminent members of the Anglo-American Pike's Peak Expedition, whose report was published in 1913.

The further we go on our way with those scientific investigators the further will be removed from our eyes the vision of pure beauty and the web of romance which poetic and adventurous pioneers conjured up before a now distant generation. Those hardy "men of feeling" scattered throughout the world gloriously painted pages. Their tribute to the Alps has been collected by their late followers, namely, Harold Spender, in his magnificent volume, "In Praise of Switzerland," and Arnold Lunn, in his "The Englishman in the Alps," and in the "Oxford Mountaineering Essays." Their song is an after-ring of Byron's lines:

"Mont Blanc is the monarch of mountains;
They crowned him long ago
On a throne of rocks, in a robe of clouds,
With a diadem of snow.
Around his waist are forests braced,
The avalanche in his hand;
But ere it fall, that thundering ball
Must pause for my command.
The glacier's cold and restless mass
Moves onward day by day;
But I am he who bids it pass,
Or with its ice delay.
I am the spirit of the place,
Could make the mountain bow
And quiver to its cavern'd base—
And what with me would'st *thou?*"

This apostrophe we may look upon as an indignant challenge of the poetic mind to the scientific.

CHAPTER III

The latest British experiments on the respiratory function of the blood at a great height on mountains—The latest French views on the same topic—The "even tenour of one's way" after adaptation.

We have allowed ourselves to wax somewhat whimsical while following Captain Spelterini to his altitudes of happiness. Let us now resume the sterner tenour of our way, and turn to the British experiments which have come, quite lately, to confirm and set the seal of finality upon the research of others, like an umpire's word arising above contending parties.

The British experiments we have in view were made in 1911, but the general public did not then get any knowledge of them, owing to the length of time that was required to put the results of such delicate research work in a shape which the ordinary reader could digest. It has been my privilege to read in the proof Mr. Barcroft's report to the Royal Society, whose generous financial assistance made it possible, with the support of others, to carry out those experiments on Monte Rosa. I have now before me Mr. Barcroft's book, "The Respiratory Function of the Blood," published just before the War, and had the pleasure of being shown over Mr. Barcroft's physiological laboratory at Cambridge.

In August, 1911, Mr. Joseph Barcroft, a Fellow of King's College, Cambridge, and his colleagues, Messrs. Ff. Roberts, Fellow of Clare, Mathison and Ryffel, spent a fortnight on the Italian side of Monte Rosa, at the highest altitudes, conducting experiments most careful and prolonged, and the more reliable as they could be checked and verified by work done before on the peak of Teneriffe, with Mr. Haldane, and other work going on at the time at the observatory of Pike's Peak, Colorado (altitude, 14,000 feet). On Monte Rosa, Mr. Barcroft and his friends carried out their experiments first at the altitude of 10,000 feet and then of 15,000.

My readers should now take in and inwardly digest at once the reminder that those experiments were by no means made

with a view to recommending the top of Monte Rosa as a health resort. It would be cruel to expect them to have the iron constitution of Mr. O. Eckenstein, who wrote to us that so far as he himself is concerned his experiences with regard to varying pressures of air have never led him to feel any difference whatever. He has done hard physical work under a pressure of three atmospheres and also at heights of 20,000 feet as well as at the intermediate pressures. He has tried whether his uphill pace was appreciably affected at any height he has ever attained, but never could trace any effect. He once spent an afternoon at the height of over 13,000 feet chopping wood: no effect! On another occasion he did exceedingly hard work at a height of over 17,500 feet, up to the limits of what he could do: no effect! Further on will appear again Mr. Eckenstein's name connected with the experiments of Mr. Barcroft on Monte Rosa, and with the scientific explanation of his case.

The purpose of Messrs. Barcroft and Roberts was to watch the behaviour of the organisms of quite ordinary men under extraordinary atmospheric conditions so that they might be seen working under a strain. Let me say that the human organisms selected bore the strain well. Though they did not escape symptoms of mountain sickness, there were no derangements of the heart, no inconvenience amounting to bad health. At our highest European altitudes, healthy men need get no harm, though one's system is undeniably, in the case of a casual visitor from the plain, making the "best of a bad job."

Now for Mr. Barcroft's conclusions. I call them Mr. Barcroft's, though I take full responsibility for the somewhat popularised form in which I am now about to express myself:—

1. Where Gaule and his school see a pullulation of blood corpuscles, by a kind of generative process following upon altitude, Barcroft would rather have us fix our attention upon the concentration of the blood by loss of some of its liquidity at an altitude, with ensuing shrinkage of the blood corpuscles. Their smaller size and larger number in any given volume of blood would thus be accounted for without *sudden* multiplication.

But mind the reservation: living *at* an altitude, as distinct from going *to* an altitude, does result in an increase of the number of blood corpuscles. This increase is permanent and constant; it becomes manifest after a residence of a few weeks above 10,000 feet. Under that limit the change in this respect is less definite, and I should say, on that account, more salutary, because easy.

2. The function of hæmoglobin, the red colloid molecule of cell matter in the blood, is that of a *carrier* of oxygen. The corpuscle is the boat that loads the oxygen at a wharf called the lungs, and discharges it at landing stages all along its way throughout the muscles, the brain, or any tissue, to be used up in a chemical process. At high altitudes (above 10,000 feet) the tissues begin to suffer from oxygen want. To meet this call, the amount of blood which leaves the lungs increases, perhaps, twofold. Each corpuscle is a ship with its little cargo of oxygen, and twice as many as before leave the lungs. Along the arteries the fleet rushes to the tissues and unloads the wherewithal to replace used-up material in the nearest blood factory, to build up fresh works and to provide forces to drive the manifold machinery of blood life (bio-chemical processes). At an altitude there is a speeding up of the whole business. The *loading* is speeded up by panting (altitude 15,000 feet), and by increased rapidity and energy of the heart beats. The *unloading* is speeded up, as shown by an abnormal production of lactic acid which diverts to itself the oxygen of the blood at an increased velocity and uses it up.

3. In the natural course the combustion of oxygen in the body culminates in the production of carbon dioxide. At any altitude which may be accounted a cause of fatigue, an undue proportion of lactic acid displaces some proportion of carbonic acid, should there be a shortage in the oxygen supplied to the engine. With sufficient oxygen extraction from the air combustion is complete, as in the explosive engine used on motor cars, carbonic acid being the proper discharge from the human engine of respiration when in good order. But lactic acid supervenes under conditions of strain in the same way as incompletely burnt products escaping through the exhaust pipe of a motor car. Lactic acid proceeds from incomplete combustion of living substance, and in its turn calls for an accelerated flow

of oxygen from the blood vessels to repair the mischief, that is, to destroy its own injurious self in the depths of the tissues.

Moral: going from one's ordinary altitude to a moderately higher one means speeding up the system and the organic processes of life. We then go through our habitual bio-chemical gymnastics at an accelerated rate. The very temporary impoverishment of the blood, if any, is then lost sight of in the exhilaration which accompanies the lightening of the air. One walks as on springs, would say an enthusiast.

But going from one's ordinary altitude to an unreasonably high one puts a strain upon every screw in the machine, as a bad road on the body of a motor. There may ensue lactic intoxication, brain anæmia, sudden irregularities in the distribution of nervous energy.

Such researches into the respiratory function of the blood as those we have just analysed are beginning to yield far-reaching results. A critical stage in their bearing upon medical practice may be near, and then analysis of the blood may become a crucial test in diagnostics. A gulf is visibly opening between the young practitioners trained in the most modern physiological laboratories and their elders.

Mr. Barcroft, in his chapter on the effects of altitude on the "Respiratory Functions of the Blood," writes :—

"What fields of research lie in front of the physiologist before he can explain how the subtleties of climatic conditions affect the human mind, that entity of which all human activity is a manifestation! . . .

"You are one person in one place, another in another. At the Alta Vista (Teneriffe) I became as one incapable of arithmetic—I vow that I would have been at the bottom of the class with a dunce's cap on and that I could not have helped it. At Col d'Olen (Monte Rosa) I have heard two clever and distinguished physiologists pause to discuss whether or no four times eight made thirty-two. At Johannesburg I have been told that a cricket team representing England so lost their nerve that they laughed like children at quite trifling turns in the course of the game and fell an absurdly easy prey to their South African opponents. At the Margherita hut (Monte Rosa)

I have seen one of the pleasantest and most considerate of companions behave as if he were suffering from alcoholic excess in a mild degree. What of the surprise that comes to us when we hear of cautious and skilful climbers losing their lives by doing extravagantly reckless things? Such incidents are caused by the little recked-of cerebral changes which appear from time to time as the incidents of life at high altitudes. They are doubtless the effects of acid intoxication—but of this later."

The reader should bear in mind that Mr. Barcroft is here speaking of the altitudes of unhappiness—above 10,000 feet. But not all that happens up there is injurious to our system, as Mr. Barcroft himself will tell us in a moment. To continue:

"The climber depends for the most part on his cerebellum; his cerebrum takes its chance and is little considered. One day the psychological changes, which, in my opinion, appear much earlier than cerebellar ones, such as defective co-ordination and giddiness, and medullary ones, such as vomiting, will be studied for their own sake.

"In the meantime we have got the pioneer work to do; we have got to make a road into this forest wherever we can; we have got to find out the changes which take place in the blood at such altitudes, and in truth this is enough to tax our powers.

". . . There is only one conclusion: as we ascend, the carbonic acid has been displaced in the blood by something else which produces an equal effect on the affinity of hæmoglobin for oxygen. Probably this something else is another, but not a volatile, acid; it is something that does not go away in the breath. It follows from what we have said above that we should be able to discern its presence.

". . . We have said enough to indicate the possibility of a method for the purpose of estimating the effective strength of the acid, or acids, thrown into the blood apart from the carbonic acid.

". . . We walked from Alagna to Col d'Olen (Monte Rosa), an ascent of 5,500 feet (1,700 metres), in about four hours; immediately on arrival some of my blood was drawn and a determination made; the determination showed that, leaving out of account the carbonic acid, the acidosis in the blood amounted to the equivalent of ·042 per cent. of lactic acid;

this, however, was not a permanent condition, it was a mixed effect due to exercise and altitude together; at rest at Col d'Olen the acidosis amounted to the equivalent of ·02 per cent. in lactic acid. After we had been at Col d'Olen some ten days we went up to the Margherita. The ascent was about 5,000 feet; we made it in seven hours, out of which we rested for perhaps an hour at the Capanna Gnifetti; on reaching the summit there was again a further large accession of acid to the blood. It reached ·54 per cent. This again had ebbed to some extent by the following morning. At present we are only discussing the question of the condition of the blood when the person under observation is at rest or at all events not exerting himself. There is the most distinct and definite evidence that the blood changes at each different altitude, that apart from the carbonic acid present the blood gains in acid or loses in alkali, at all events that its reaction alters in the direction of decreased alkalinity at the higher altitudes.

". . . The lactic acid at Pisa (low level base of comparison) and Col d'Olen was practically the same, whilst at the Capanna Margherita there was a sensible lactic acidosis.

"Our Monte Rosa expedition, therefore, left us in the following position. We found:—

"1. In common with previous workers, that the higher the altitude the less the carbonic acid in the alveolar air (air collected from the lungs) and presumably the less in the blood.

"2. The higher the altitude the more marked the acidosis in the blood when the carbonic acid is shaken out of it.

"3. At any altitude the acidosis and the diminution of carbonic acid so nearly balance one another that the reaction of the blood remains practically constant. . . .

"What acid is responsible for the acidosis in the blood has yet to be ascertained; it is clearly not lactic acid or any of its close relations; on the other hand, it may be that there is no increase of acid at all, but rather a diminution in the amount of alkali present. . . . So far we are left without a knowledge of the mechanism of the adaptation which we have discovered.

". . . A few lines back we spoke of the altered condition of the blood as an 'adaptation' to the altered conditions of barometric pressure. In doing so we introduced a fresh idea into

our narrative, namely, that the change in the blood was beneficial to the organism. This is true ; so far we have treated the matter merely as an interesting observation, . . . but the alteration of the individual factors while the balance is preserved leads to very important results. Over any considerable interval of time there is always a certain relation between the carbonic acid in the alveolar air (air enclosed in the lungs) and the oxygen in the same.

"The proportion of the one to the other depends upon the respiratory quotient and ultimately upon the food that is eaten.

". . . There are two points in the above argument which have been passed over rather lightly, because the argument itself only demanded the mere mention of them. Yet they are both of considerable interest on their own account. They are the following : firstly, why did I become acclimatised at once on Monte Rosa when I did not at Teneriffe ? and, secondly, why did Douglas acclimatise at Teneriffe when I did not do so ? The fundamental principle is that acclimatisation is due to oxygen want. In order that you should acclimatise satisfactorily you must do so gradually, and therefore court oxygen want from the beginning of the ascent ; then the acid gradually finds its way into the blood and the carbonic acid gradually finds its way out. The most satisfactory way of doing this is to walk up the mountain. The difference between my ascent of Monte Rosa and that of the Peak was that the former was made on foot, the latter on a mule. As regards the acidosis when I reached the Col d'Olen there was no doubt. Some of my blood was taken directly I arrived there ; . . . at each effort of climbing there was an acidosis which only partly disappeared in the ordinary life of the place.

"An interesting point was the fact which we discovered on coming down to Col d'Olen from the Margherita hut, that the acidosis which had been induced by going there remained some time and materially strengthened our position owing to the lowering of the carbonic acid pressure and the corresponding rise in oxygen pressure. The beneficial effect of exercise at high altitudes is of course commonplace amongst the persons who frequent mountains, and especially the benefit derived from going up a little higher than the point at which one is

living, and then coming down again. Our results show that this benefit is no intangible affair which may be vaguely included under the general term 'training,' but that it is a very definite change in the blood of the individual which may be detected by the chemical analysis of that fluid.

"There is no difficulty then in stating the reason why I should have become acclimatised when I walked up the mountain and not when I went up on a mule—in the former case the effort of the climb induced oxygen want and consequently acid production, in the latter case this element was absent.

"To answer the other of the two questions set above, why did I not become accommodated at Teneriffe when Douglas did so? is at first sight more difficult, as the consideration of mountain sickness is bound up with that of exercise at high altitudes."

In the next and last chapter of his book Mr. Barcroft takes up this question of exercise at high altitudes, and says:—

"I cannot for a moment suppose that any appreciable degree of meionexy (the taking up by the blood of less than the usual percentage of oxygen) would be induced by a walk from, say, Fort William to the top of Ben Nevis whether in seven or eight or ten hours. The only symptoms from which the pedestrian would suffer would probably be those of cold. Not so when we arrived at the Margherita hut. At all rates of climbing the effect of altitude to all intents and purposes is quantitative; the effect is clear at 15,000 feet; it is not to be found at low levels. It is in fact an acid intoxication. . . . We must ask two questions:—

"1. To what extent did acid radicles appear in the blood?

"2. What were the acid radicles which appeared?

"Here again we must recapitulate what has been said about acidosis in the last two chapters. The acidosis due to exercise appears to be a lactic acidosis, that due to altitude does not appear to be a lactic acidosis at altitudes of 10,000 feet, though at altitudes of 15,000 feet there is some degree of lactic acidosis.

". . . Relative increase in the oxygen pressure [in the circulation] has a twofold effect—it increases the rate at which the blood can acquire oxygen in the lung and it increases the limiting percentage saturation. In effect it brings you

thousands of feet down the mountain again. So even from the chemical point of view the blood is not under such bad conditions in the lung after all. The meionexy reduces affinity of the blood for oxygen, but indirectly betters the conditions for its acquisition. What it takes away with one hand it gives back with the other. It is not all loss in the lung, and in the tissue it is all gain—to the organism.

"The adaptation to altitude, being, as I have said, a compromise, must break down if the conditions become too severe, that is to say, if the altitude becomes too high for the necessary exercise, or the exercise too great for the altitude; the result is mountain sickness. I have sometimes been asked the following question: If the effect of altitude is merely to produce a given degree of meionexy with a less degree of exercise, why are the *final* effects of exercise at low and high altitudes different? No one suffers from mountain sickness in, say, the University sports, though the effects of meionexy are evident enough. Mountain sickness is doubtless caused by want of oxygen in the brain itself. It is not merely that the vomiting centre is stimulated by a meionectic condition of the blood in the general circulation. At high altitudes even tissues which are comparatively inert are suffering to some extent from oxygen want; or at least to prevent their so suffering there is some degree of dilatation. The result of this dilatation, combined with faulty oxygenation of the arterial blood, is to reduce the supply of oxygen of the medulla to a minimum. Then some trifling change takes place: the wind meets you in the face and you hold your breath; the digestion of food, or perhaps even the contemplation of it, sends an extra supply of blood to the abdomen; sleep comes, and the blood tends to leave the brain. Any of these will make you feel sick. The actual symptoms of mountain sickness resemble those of hæmorrhage rather than of exercise.

"Is it possible to tell those who are likely to suffer from mountain sickness from those who are not? It is difficult to say without studying a much larger number of cases than those which have already been subjects of research. In Teneriffe the individuals whose bloods had the smallest affinity for oxygen at a constant carbonic acid pressure suffered least from mountain sickness. . . .

"Between the dates of the Teneriffe and Monte Rosa expeditions two mountaineers of eminence were kind enough to give me blood for analysis. These were Oscar Eckenstein, who claims to have lived at an altitude of 20,000 feet longer than any other man, and Longstaffe, the Himalayan explorer. The fact that the blood of these two persons when exposed to the standard carbonic acid pressure gave lower values for alkali than any other human blood that I have analysed was an interesting confirmation of my theory."

To keep the balance fairly even between French and English investigators we shall now return to Dr. Bayeux, who has been as amiable as Mr. Barcroft in supplying me with relevant material. He says :—

"Several scholars have given forth the opinion that the extraordinary multiplication of blood globules ascertained by means of enumerations made at high altitudes does not point to an actual new formation of globules, but only to a *relative* increase in their number due to the concentration of the serum of the blood under the influence of the lowering in barometric pressure. The following notes bring a new contribution to the decision of this question; they show the results which have accrued from investigations which we undertook in 1913, regarding our venous blood and the arterial and venous blood of several series of rabbits, at Paris, Chamonix and Mont Blanc. The Chamonix tests were carried out in M. Vallot's laboratory (altitude 1,050 metres); the Mont Blanc tests in the observatory at Les Bosses (4,360 metres). To study our own venous blood, we punctured a vein in the bend of the elbow. In the case of the rabbits we drew blood from the femoral artery and vein. The blood was set to coagulate in hermetically closed tubes, and the serum was examined eighteen hours after. The *indices* were determined by means of the Pulfrich-Zeiss refractometer. The weight of the albumins was worked out per litre of serum (ratio). The experiments lasted two months at Chamonix and nine days on Mont Blanc.

"They showed that the serum had undergone concentration when passing from the lower to the higher altitude and that on acclimatisation the concentration was reduced at both altitudes. A greater concentration was observed at the beginning of our

stay on Mont Blanc—I am now speaking of our own blood—in the case of the one of us who was just recovering from mountain sickness. If from our human blood we pass to the consideration of that of the rabbits—regarding the venous blood as in our case—the serum was more concentrated than in arterial blood—as between the rabbits—in almost every instance. The concentration in the blood of rabbits is not so great as in the blood of man.

"To sum up, the figures which we obtained admit of the following enunciations :—

"1. The refractometric index of the serum of the blood is higher on Mont Blanc than in the lowlands and at Chamonix.

"2. To the serum of venous blood belongs a higher refractometric index than that belonging to arterial blood.

"3. The difference between the index belonging to arterial blood and that of venous blood is more pronounced on Mont Blanc than at the lower altitudes.

"4. Accordingly there is a concentration of the serum of the blood consequent upon passing to higher altitude.

"In fine, this concentration, for the most part, is a concentration of albumins. But we do not put this affirmation beyond recall. We intend to submit it to verification when we next ascend Mont Blanc, for this and other cognate purposes." (From "Comparative Researches upon the Concentration of Arterial and Venous Blood at Paris, Chamonix and Mont Blanc, by the Refractometric Study of Serum, 1914.")

"Looking away from the cases of critical asphyxia or syncope to which one is exposed when one ascends to the highest regions of the atmosphere, the most common symptom of general ill-being is distaste for food, often accompanied by nausea and vomiting. One may even affirm that this repulsiveness of food belongs to all the forms of ill-being at altitudes. Aeronauts may fall a prey to it as much as climbers, and these are even most subject to it when they have found shelter out of the reach of weather. Accordingly this symptom may not be attributed to cold or fatigue : the relative deprivation from oxygen is the most plausible cause.

"I wished to analyse the mechanism of this anorexy and, in September last, 1910, I studied the variations consequent upon very high altitudes in the quantity of secreted gastric

juice and in its total acidity. The subject of my experiment was a dog which had been operated upon in Paris for a gastric fistula. The linked experiments in Paris, at Chamonix and on Mont Blanc authorise the following conclusions :—

"1. The quantity of gastric juice secreted during a given time, after a meal that is always the same, diminishes considerably during a stay at a high altitude.

"2. The total acidity of the juice undergoes only slight diminution under those conditions.

"3. The general activity of the gastric juice is much delayed in its operation.

"This slowing down in the secretive activity of the stomach bears out the general slowing down in the circulatory combustion elsewhere demonstrated. The poor supply of gastric juice explains the loss of appetite. It seems to me also to explain the greed one experiences, at a very high altitude, for condiments that are apt to stimulate gastric secretion or palliate its absence, such as lemon juice, vinegar and spice." (From "Experiments made on Mont Blanc on Gastric Secretion at a very high Altitude.")

"While injections of oxygen into the veins instance as it were certain accidents arising from the slackening of blood pressure, injections of carbonic acid determine accidents akin to mountain sickness. In the case of dogs in which as much carbonic acid had been injected as they could carry, I have noticed nausea and vomiting, the ordinary concomitant of mountain sickness. In the case of several rabbits which I had brought to the extreme limit of asphyxia, though their heart was quite free from gaseous bubbles, I saw, on restoring the freedom of their movements, that the first stirrings of their limbs brought on sudden death.

"Now, it is on record that alpinists suffering from mountain sickness have died suddenly after resisting for long hours asphyxia and that some aeronauts have been struck down when performing muscular efforts of short duration. In the case of these, however, their sudden death had not been preceded by any visible distress. It is possible to reproduce such conditions by the gradual injection of carbonic acid ; this brings on asphyxia in an attenuated shape which may reach the fatal point little by little. Death by oxygen want is thus due to a gradual

stoppage of the circulation, and death owing to carbonic acid is a genuine asphyxia." (From "Comparative Resistance of the Dog and of the Rabbit to the Injection of Carbonic Acid into the Veins.")

So we may ascribe to two distinct causes the fatal termination of certain mountaineering accidents. Oxygen want accounts for one set of symptoms, and acidic poisoning of the blood for another. Those symptoms may combine, or be exclusive of each other. Collapse arising from oxygen want would probably give no warning.

Incidentally to some writing on the use of hypodermic injections of oxygen, Dr. Bayeux says :—

"There is an asphyxia with which one may rarely have occasion to become acquainted and to which I was among the first to apply this treatment—anoxhæmia (insufficient oxygenation) at altitudes. This question wears quite a serious aspect now, when the progress of aviation is superadded to alpinism as an inducement to frequent the highest regions of the atmosphere.

"I have for ten years now carried on experiments with physiological activities as my field of observation at the Mont Blanc observatory. In the course of those years I have had opportunities for watching several cases of acute asphyxia arising from mountain sickness, but it was not till 1911 that I had before me the actual, ocular proof, and this proof was afforded through the instrumentality of hypodermic oxygenation.

"With a view to affirming that high altitudes bring on asphyxia, a point of comparison to lean upon had always been wanting. The relevant phenomena were studied as they presented themselves, at Chamonix before and after the expedition, on Mont Blanc at each altitude of observation : one did not compare at the same time animals at Chamonix and on Mont Blanc.

"I solved this problem by oxygenating animals in the Vallot observatory (4,360 metres), and comparing them with animals uninterfered with in both places and at the same moment. The blood of rabbits, after staying a fortnight up there, showed asphyxia when artificial oxygenation had not

been administered, while the blood of the oxygenated specimen remained normal.

"This experiment shows: (1) that anoxhæmia is a fact at high altitudes; (2) that it may be overcome by injecting oxygen under the skin into the tissues. Would it be possible by the same means to overcome the distressing symptoms to which some of the most terrible accidents known in the sport of aviation appear to be due? We are now studying that question. The *technique* of hypodermic injections is most simple, with the usual antiseptic care and proper apparatus." (From Dr. Bayeux' Paper read at the First International Congress for Comparative Pathology, 1912.)

Let us now look away from all those extreme and distressing situations. The enrichment of blood is, we have seen, spontaneously provided for by nature out of her bountiful stores. Nature is not chary. She does not beg for our help. *Natura medicans* is not, as some would have it who are ever ready to drug her, *natura mendicans*. She does not beg at the apothecary's shop, and she will bring forth the sturdiest samples of humanity, or allow them to bloom unhindered, wherever her action can extend. So we need only add a few remarks on the equilibrium of health and habituation in the case of those who are only visitors in the Alps.

We have set forth the *internal* process of adaptation to altitude, and our readers have seen how purely natural it is. The few external features by which it is accompanied may be shortly recalled here because it is obvious that an increase in the number and power of the respiratory elements of the blood cannot take place without some dependence upon more external physiological functions. Deep-drawn breathing, circulatory impetus of the blood and all secretions, general nourishment, too, have their influence on increased blood production. Permanent dwellers at an altitude have occasion to observe this when they expose themselves to being surfeited by moving to lower levels. It is with most of them an unpleasant sensation, and often they will not tolerate the change.

What interests us more is to perceive the increased health, strength and buoyancy of those who expose themselves to

stimulation by the opposite process. But we cannot use, for purposes of comparison, any other observations than those which we can make on one and the same individual on passing from no-altitude conditions to altitude conditions. The observation of communities living from generation to generation at any given altitude consistent with the normal life conditions of the human kind would supply no elements of comparison as among their members owing to the completeness of habituation not only in individuals, but also by collective heredity. Nevertheless, we shall at a later stage study the health conditions of the only two communities in Europe living constantly at an extreme altitude, and these we select, not because their altitude is extreme, but because it is a useful, or a natural one, for them to dwell at constantly. Those communities are the peasants of Avers and the religious confraternity on the Great St. Bernard, the former being a purely natural settlement and the second one for which the motive power was not nature-given.

People who have spent some days on the heights will often have something to say about being out of breath. To put it scientifically, the greater the altitude, the greater will be the frequency of inspiration and expiration (inhalation and exhalation of air by the lungs). This greater frequency stands to reason. We have already stated its cause. There being less air in any cubic volume, and the same quantity of air being demanded, the opening and closing of the pulmonary bellows must undergo quick repetition. A certain weight of oxygen is required, and this being dispersed in a larger field of air, as it were, the breather is very much in the position of an animal set to browse where the grass is thin. Such an animal must close and open its jaws oftener to collect the quantity of grass it is accustomed to. In the case of man, when the enrichment of the blood has taken place, the greater frequency of the breath is shown to have been a temporary device pending adjustment. Mountaineers are slow breathers who do not get out of breath and do not like to be hurried on by a novice from the plains. Our mountaineer is in the second state of the browsing ruminant which, when it has found that grass is of much better quality at an altitude, so that less of it is sufficient to feed it as well as in the plains, need no longer over-

exert itself. But, if the greater frequency of the muscular action of the lungs need not endure, the greater amplitude of their action becomes a habit, and a most salutary one it is. The mountaineer is a slow but *deep* breather. For about six metres of air on the seaside approximately nine are breathed into the lungs at the altitude of 2,000 metres. After a more or less prolonged period of habituation, the data of the experiment become less and less conclusive. The mountaineer does more work on smaller expenditure. His calmness and precision are proverbial.

Chronic shortness of breath, whether nervous or catarrhal, may be relieved by repose at a moderate, sunny and dry altitude.

We have seen in obedience to what imperious force—need for speedy re-oxygenation—the circulation of the blood between the lungs and the heart is faster, pulsations more frequent. If time is given for habituation an approximate return to the normal may be observed.

But there is no such thing as intra-arterial tension to be reckoned with. One used to hear a great deal of that in former days, when the weight of air above one's shoulders was compared to a solid column representing a terrifying number of kilograms. It used to be taught that the diminution in the pressure of the air from outside upon the coating of the blood vessels would leave their outer tunics unprotected against the pressure from within to which they were exposed owing to the propulsion of the blood. The mistake about this is to forget that the diminution in pressure takes effect throughout the organism. If there is any change in arterial pressure from within upon the tunic of the blood vessels it is so slight as to be practically of no import. The thinning or the drying up of such tissues by sclerosis is a physiological form of decay which is universal and cannot be attributed to any special cause affecting any given altitude. Increased arterial tension as a cause of hæmorrhage does not particularly affect dwellers at an altitude, and is not a characteristic cause of death with them. Alpinists, balloonists and valetudinarians are exposed to certain hæmorrhages, maybe, but for these the cause is to be sought in a state of bad health which is personal, or the hæmorrhage occurs at altitudes that are quite extraordinary.

We have seen how, by a rise in altitude *to lowered pressures*, there is at first a diminution in the quantity of oxygen passing through the lungs, and organic combustions undergo a proportionate reduction. From this they recover very soon, oxygenation rising for a while above the normal and then returning to its ordinary amount by habituation. There is, none the less, an increment, as exercise at an altitude, however slight it may be, accelerates combustion at a greater rate than on the lowland.

The secretions of the body we have still to consider. These, so far as they are eliminated in a liquid shape, are less pressing at altitudes. Between flatlands and highlands there is such a difference in atmospheric drought and density that the air on the heights considerably increases the quantity of moisture passing through the skin, while that which we take in through our lungs is reduced. Evaporation through our lungs also is greater. But here again habituation works its effect. That the body gives out much more aqueous matter in the form of vapour than on the lowlands is sure. But it is difficult to speak more definitely, as the more or less liberal quenching of thirst is an incalculable individual datum. Mountaineers drink very little water, but, leading as a rule pastoral lives, milk plays an important part in their diet. As a rule, *moving to* an altitude develops thirst.

Is the temperature of one's body higher at an altitude? One would expect it to be lowered, in so far as refrigeration must ensue on an increase in evaporation. In practice, and allowing for a short interval in which the keenness of mountain air will be resented, one will find that it is not so, and that the somewhat increased physiological labour forced upon the organism in the process of oxygenation has, on the contrary, a tendency to raise one's "specific" temperature.

As a rule, dwellers at an altitude are spare-built and unencumbered with fattiness. But those leading a lazy life and overfeeding need not expect to escape from the penalty. The principles of hygiene in food and drink and sleep are just as exacting on the heights as on the sea-level.

The conclusion to be drawn from observation is that a perfect physiological equilibrium subsists at our European latitudes between the high places and their population. One may

almost say that the best conditions of lowland life and the best conditions of highland life give the same chances of good health to communities who are sedentary at either level. If we take Switzerland as an example, we find that the tallest and best developed manhood, from the military point of view, are found to reside indifferently in the Canton des Grisons, which is typical for the mountain life of its community, and in Geneva, which is typical for an active and crowded existence in a town which, from several points of view, is not particularly healthy. If we wish to become aware of the differences, which are real and great, and to become aware of the greater salubriousness of Alpine altitudes, we must diversify and specify. And when we speak of the good to be got from moving into mountain air we must individualise. With an equal regard, or disregard, of sanitation there is not very much to choose between a lowland climate and a highland climate for a permanency. But selected bad healths and normal healths at a low ebb will improve on removal to an altitude. Then spontaneous reselection may take place within a community of bad healths brought together. Large artificially selected communities do now exist in the Alps, consumption being the touchstone. How they may compare with the communities spontaneously arisen there on economic and natural grounds remains to be seen. Meanwhile, a consideration of these will be a new, and not uninteresting, chapter in the study of demography.

CHAPTER IV

The colony of Augustinian monks on the Great St. Bernard Pass—The rural community at Avers—The statistics of Canton Grisons (Graubunden) and Canton Valais (Pennine Alps)—Corresponding Swiss statistics.

The two communities which we wish to study more closely because they are situated at the highest altitude inhabited in Europe have, however, nothing to do with the cure of consumption. That in Avers has been there ever since it was found that the valley could support, by means of its own resources, a large number of families on meadow land, grazing and forest. The other, the Great St Bernard Pass, was called into existence by the promptings of charity, in order to extend help to wayfarers exposed to the rigours of an arctie climate on their journeys between Switzerland and Italy. Those communities differ absolutely from each other, and are alike only in this, that none dwell higher in Europe. They may on this account be fitly introduced here, because each will serve to illustrate the matter of habituation to altitude in an aspect totally contrary to that in which the other appears, and yet leading to congruous conclusions.

We shall take the Augustinian monastery first. Situated exactly on the Pass, at an altitude of 8,120 feet, the hospice stands in the worst possible position that could be selected for a dwelling-place. The only protection against wind and weather is afforded by the thickness of the walls. On one side of the road stand the church, the quarters of the brethren, and the rooms for travellers. On the other side, another building contains storehouses, further accommodation for wayfarers, etc. Travellers are boarded and lodged gratuitously, but those who can afford it may voluntarily defray the whole or some part of the hospitality they have partaken of. The rules of the brotherhood are those of the Augustinian Order. The community permanently in residence consists of fifteen monks

and from seven to ten attendants or lay brothers. All are recruited at the age of twenty or thereabouts from the well-to-do peasant homes in the Canton du Valais and in Savoy. Young men of inferior stamina are, quite naturally, rejected. There is thus a kind of selection, and, in addition to being sound in limb and body, the brethren are taken from a mountain-bred stock.

On the other hand, as on retiring from duty at the hospice the brethren join the clergy as incumbents in parishes reserved for them, they are selected on intellectual grounds as much as for their *physique*. We are therefore in presence of a community of students doing for charity's sake a work of mercy, and seeking at that altitude neither health nor a livelihood. They form a colony without any autochthonic roots. They were not born there nor brought up there. They were not born from parents who had ever dwelt there. Their habituation is purely personal and, within the community, entirely individual. Their occupation is neither agricultural nor pastoral, neither has it anything to do with commerce.

They live at that altitude, and in the employment for the sake of which they are collected there, for fifteen or twenty years, these years being the best of their lives for habituation, extending as they do from early manhood to the fullness of manhood at forty. On reaching that age, or approximately, they are set free from their obligation to the monastery and may leave to join the clergy. Their life is, in a sense, like that of soldiers quartered in barracks, or like that of the scholars or fellows resident in a college. They do not live within the bonds and ties of domestic life, neither do they share in its health-giving potentialities. They are an assemblage of male individuals succeeding one another at a very high altitude—considering the latitude—for a definite purpose. At an age when they may no longer be trusted to fulfil that purpose adequately, and lest they become in the end a burden upon the community, they are transferred to another sphere of utility. Their conditions are, as one feels, artificial, in this too, that they are not called upon to endure old age and to reach the hour of death at the place and under the conditions which marked their prime. To use a convenient German word for which the English language has not yet coined a suitable equivalent: the St. Bernard community is not *naturwuchsig*.

On leaving the monastery on the St. Bernard Pass, some of the brethren serve a second term in the hospice on the Simplon road. This lies about 1,500 feet lower, but is also an extremely inhospitable spot for want of shelter. Those that are aged before their time or have contracted some infirmity may retire to the hostel at Martigny, where the Provost and the Procurator-General of that section of the Augustinian community are in residence.

The novices and brethren being for the most part intended to become priests, care is taken that previous to entering the Order they should have completed their literary studies. They then go through their philosophic and theological course at the hospice, which hence may be looked upon as a seminary. Consequently, if we leave to one side those brethren to whom is particularly assigned the duty of administering to the wants of strangers and wayfarers, the brethren are all occupied throughout the long winter in studying or in teaching. From this business of receiving and giving instruction they are, however, frequently called away to patrol, as it were, the Pass, to search for travellers who have gone astray and accompany the feeble.

The daily time-table is as follows : They rise at five o'clock in the morning during summer and at half-past five during winter. Then religious exercises and church offices within monastery and church occupy them till the hour of breakfast. For this they have coffee and milk and bread with cheese. From eight o'clock to mid-day they are engaged in study. At mid-day dinner is served, with meat five times a week, except in Lent, when fresh fish is abundant, supplied from Italy. The dinner is short. Physical exercise ensues. Whenever weather allows it the brethren are turned out, with ski, on the hillside for a short outing. They are called to resume indoor study from two o'clock till half-past six, with an interruption of one hour at four o'clock for attendance at church. At half-past six supper is served, with meat five times a week, as for dinner, followed by an "off" time for recreation, then the singing lesson, then the evening prayer. By half-past nine all the brethren retire to their cells and seek rest for the night. This is not unfrequently disturbed by midnight divine offices.

Once a week, whether wayfarers be reported on the Pass or

not, and under all conditions of weather, the whole troop of monks is led away for the day on a "hardening" trip among the hills. They are sufficiently provided with food and with plenty of spare clothing, for such outings sometimes imply great hardship.

Does such a *régime* conduce to hardiness? The Provost tells me that the exceptionally robust among his company do not thrive quite as much as those who, on joining the station, showed some disposition to anæmia and nerves. The utmost interest attaches to this distinction, as we have to deal here with individual habituation. The sedentary life forced upon the monks would seem to tell upon those endowed with powerful constitutions, in the long run, unfavourably, as it must anywhere, when out of proportion with an abounding and exacting vitality. On the other hand, the full benefit of removal to an altitude tells favourably upon the less powerful constitutions, the daily periods of mental work indoors being in their case fortifying and recuperative.

After fifteen or twenty years of seclusion at the hospice it is found that the cases of loss of physical vigour, of chronic indigestion and rheumatism affect the muscularly and constitutionally powerful members of the congregation. These are then transferred to active work in parishes extending over much hill and dale, and this plenitude of outdoor life sets them right again in a few years. The brethren are free from infectious and eruptive diseases. A few "colds" or cases of bronchitis or laryngitis do occur on the approach of spring, and that is all. But, should an infectious disease be brought to the hospice by wayfarers—an unavoidable occurrence, as these belong to the most wretched and improvident classes of society and the brethren go among them in a spirit of charity so unenlightened that recklessness is reckoned a merit—the disease in question has been known to pass from those who brought it to the inmates of the monastery.

So long a sojourn in the hospice, followed, as we have seen, by removal before old age to happier climes under a less stringent rule of life, seems to comply sufficiently with the requirements of health to have no effect upon the length of life. Many of the brethren reach the age of seventy, or eighty, or eighty-five, while others who are taken away earlier, are not in numbers

sufficient to enable the brethren to lay a claim to extraordinary mortality. Yet the exposure to cold and reduced air pressure is continuous and should be able to work its worst. It does sadly affect the wretched, ill-clad passers-by. These are mostly the appointed victims of mountain sickness. They are besides in such an impoverished state of health, or so unable to take nourishment owing to feebleness and indigestion, that a reaction is impossible.

But, as the Provost humorously reminded the writer, if men and horses gradually recover, the ailment is beyond remedy in the case of motors and aeroplanes. The hospice has a Diesel engine of 20 H.P., now reduced to 16 by chronic mountain sickness. The motor van which the monks triumphantly invested in a few years ago they have had to abandon as unprofitable because the load for which it was nominally calculated turned out to exceed its power as soon as the altitude of 2,000 metres was reached. Aeroplanes, adds the witty Provost, he has seen when a large supply of condensed air brought up in tubes and poured forth to float them in—as oil is poured on the sea—would have spared their pilots a sorry plight. This was in the early days of air navigation.

We subjoin tables which will show at what age the brethren decease. It will appear on perusal that the very prolonged stay of the brethren at such high altitudes and under circumstances that are in some ways critical did not to any perceptible degree diminish their chances of a long life elsewhere thereafter. These statistics cover such a long period that, though the community is small, their validity cannot be disputed. The conclusion may be drawn that persons, at any rate of the male sex, individually acclimatised on the Great St. Bernard Pass, are proof against infectious and zymotic diseases for the period of their lives spent there, and that there is no question of their contracting tuberculosis.

It is precisely between the ages of twenty and forty that infectious, zymotic and tubercular diseases are most apt to be contracted with fatal results. After forty, the development of the latent tuberculosis with which we are all more or less afflicted from the first breath we draw in inhabited places is almost always connected with a previous debilitation of the system. Two of the brethren brought with them the

tubercular taint and died at the ages of twenty-seven and thirty-three, after spending, the first eight years, and the second thirteen years, at the hospice. They caused absolutely no infection. They had joined the confraternity together in 1844.

An analysis of the following tables shows that, by 1914, there were 53 recorded deaths out of a total of 72 brethren who entered between 1821 and 1880. Out of these, 19 are still alive, all born before or about 1860, the minimum age of these being 54.

I.—Table of Ages at Death.

Age at death . .	21–30	31–40	41–50	51–60	61–70	71–80	81–90
Number of deaths .	6	11	2	15	11	6	2

II.—Present Age (Spring 1914) of those still Living.

Above 54	Above 55	Above 60	Above 65	Above 70	Above 75	Above 80	
1	4	4	4	1	4	1	— Total . . 19

III.—Deaths at the Hospice.

	Typhoid.	Phthisis.	Peritonitis.	Epilepsy.	Avalanche.	Accidents.
Number of deaths .	3	2	1	1	2	2
Age at death	39, 32, 31	33, 27	24	28	27, 22	60, 41

IV.—Number of Years spent in Hospice.

	Under 5	Under 10	Under 15	Under 20	Under 25	Under 30	Under 35	Under 40	Under 45
Brethren	3	14	26	15	7	2	1	1	2

The causes of the 11 deaths in the hospice are practically all accidental. The three fatal typhoid cases date back to the year 1839, when the disease was brought into the hospice by passers-by. The cases of phthisis arose from a contamination that had escaped observation at the time of admittance of those two brethren. The peritonitis was a case of exposure. The epileptic case calls for no comment. The purely external cause of the other four deaths is obvious. The actual causes of the death of the 42 brethren having left the hospice are immaterial to the issue, as they clearly died at ages when an influence specifically injurious to life at such an altitude, if any such influence existed, had got completely merged in the ordinary causes of death at their age.

In this connection the reader should notice critically the table giving the length of time spent at the hospice. If there could be anything inherently injurious in long exposure to altitude under the most severe conditions which are

deliberately sought out in Europe, not as a silly challenge to nature, but for a reasonable purpose, it would appear from those tables. But the two imported cases of phthisis were not cured.

The Provost calls my attention to a peculiarity concerning those brethren who passed from the St. Bernard Hospice to that on the Simplon Pass. It would appear that though the St. Bernard statistics show nothing contrary to normal longevity, the brethren who were removed to the Simplon Pass, at a still high, though somewhat lower altitude, are those who show the longest lives. This may arise from purely individual characteristics, as the numbers are too small to make generalisation safe. But if we dare draw a conclusion at all, it would be that altitudes ranging from 1,800 to 2,000 metres are particularly indicated as procuring longevity in our European latitudes.

An examination of the St. Bernard statistics shows also that longevity is more marked since 1851 than in the preceding generation. This fact evidently keeps pace with, and bears out, even under those extremely unusual circumstances, the general law of increased longevity which characterises the second half of the nineteenth century. As a point of comparison, it is just as well to note here that the mean temperature of the seasons on the Pass corresponds with that prevailing on the 75th degree of latitude north at the south cape of Spitzbergen, sea level.

The meteorologist in charge of the observatory on the Sæntis, in a particularly open situation and a little higher than the Great St. Bernard Hospice, has now spent twenty-five winters in succession on that isolated mountain. His wife has been with him since 1888. They are both old, hale and hearty.

Should we draw from these tables the conclusion that sanatoria for lung patients should be established at altitudes which are practically on the extreme limit of Alpine vegetation and almost touch the line at which the snowfall becomes perennial? At that altitude the range of change in temperature from one extreme to another shows an interval of from 40° to 60° C. between day and night. The effect of solar light on rocks reaches, perhaps, at 2,500 metres the *summum bonum* for human beings in residence. The extreme cold and the total absence of germs in the dust are factors which probably could not be found elsewhere in greater efficacy. Still, though there

is no fundamental objection to colonising such altitudes with patients when accessible by road or by the "all-air route," newly opened from anywhere to everywhere, it seems inadvisable to recommend that one should resort to such extremities. Yet the sun can be so hot on the Italian side within a few metres of the hospice, that I have lain there in mid-winter on the top of the snow after a plentiful meal and enjoyed a long nap just as I might have done on a sunny shore at Cannes in the month of May.

Let us now turn to a very different community in the Canton des Grisons. The valley of Avers is still very little known, though it contains now two suitable hotels, which, however, have not, so far, been opened in winter. That good reason for keeping them open may soon arise is obvious from the topic of our discourse. The upper valley of Avers, from Cresta to Juf, enjoys the inestimable advantage of being practically flat and free from stones, the distance between those spots being quite four miles, on which to walk pleasantly along a lovely river. The valley of Avers has what we may call a back-door communication with the Upper Engadine at its Maloja end, at the top of Val Bregaglia. The footpath from Juf to Maloja leads over the Forcellina Pass to the Septimer Pass and thence along the Lunghino Valley past the Lunghino Lake to the Maloja Hotel. It is from Cresta-Avers a pleasant day's walk.

The real access to the valley is, however, by a post road from Thusis on the railway, to Andeer on the Splügen route, branching off to Avers. Andeer, at an altitude of 3,210 feet, is at a distance of about eight miles from Thusis, and there are fifteen miles from Andeer to Cresta-Avers. The Avers Valley runs, roughly speaking, north and south. But the stretch from Cresta to Juf, the uppermost inhabited plateau, runs north-west and south-east, giving the very best exposition to the hamlets. The valley is quite open, surrounded by easily accessible grazings, above which the rocky summits rise to an altitude of 10,000 feet at the Weissberg. The sole of the valley being at an altitude of 6,000 to 7,000 feet, and the aspect of the valley being so good, the winter days are very long and sunny; the peasants' houses, built with arolla wood, turn black under its fierce rays.

In the central Caucasus, at the altitude of some 6,500 feet, dwells a community of some 7,000 people. They live on cattle and grass crops, like the people of Avers. They are short (the Avers people are tall), nimble and sturdy. Semi-Christian and semi-Pagan, they probably derive their origin from the Georgian people, a section of which moved up from the plain below into the high-lying valleys in the twelfth century. The peopling of the higher Swiss valleys followed a like course at a like time.

The highest inhabited spots in the Himalayas appear to be situated at 13,500 feet, in the Andes, too, and at 14,500 in Thibet. As a point of comparison, so as to bring to scale the relativity of climatic altitude, we may note that the peach, apricot and walnut grow luxuriously on the Himalayas at 9,000 feet (when the ice region begins in Switzerland), pines and birches at 14,000, scrub and bushes at 17,000.

The peasant community inhabiting the Swiss valley is small. Since 1837 emigration has reduced it from, approximately, 300 heads of population to 178 at the census of 1910. But this community is absolutely typical for economic and social life, being in that respect like every and any other community in the Alps that has not been interfered with from the outside. The pastor—the community is Protestant—Mr. Otto Schneiter, has been at pains to collect for me the statistical data concerning that population which answer the purpose of the writing of this book. Medical men will probably find that the following tables are not satisfactory, because the causes of death are not discriminated according to the modern scientific criteria. For my part, I may say, quite modestly, that I have not yet come across health statistics which could be absolutely relied upon, the analysis of disease being still subject to undeniable variations. The tables I produce are simply a faithful classification of the entries in the Avers and Inner Ferrera church books. There is no medical man in residence, and it is well known that, of all peasants, mountaineers are slowest in calling in medical help and in lending themselves in any way to the statistical inquiries of health officers. But men of intelligence will read out of the following tables enough to see how much they are to the point.

The nomenclature of disease is an antiquated one, but what

may be gathered up under each head is quite apparent to the ordinary expert. He will leave to one side, as being only sociologically interesting, such entries as those of accidental death, suicide and mental insanity. He will look out for the deaths that occurred when the sufferer was affected by zymotic, infectious or tuberculous disease. He may be quite sure that in such a primitive community, which did not even possess a cart track giving access to it before 1904, and which was till then completely cut away from the resources of civilisation during eight months of the year, causes of recovery from disease were essentially spontaneous and natural, and that death arose from causes as locally engendered as can be conceived in the case of mortal man. This document on the health of an Alpine community established centuries ago on the borderland of the arctic waste in a mid-European climate is a perfectly faithful picture of autochthonic conditions such as may never again be available.

1. The reader will notice that our first table, ranging from 1882 to 1913, shows in the comparatively small number of unascertained causes of death distinct care in registering. It should also be noticed that up to the age of sixty there are only five such instances, and that the other fifteen fall within those advanced years when senile debility—which is not, properly speaking, a disease—becomes a frequent and important factor in a peasantry exposed to the stress of weather to quite an inordinate degree. The deaths from apoplectic stroke are a striking entry. What this may have to do with altitude may be worth inquiring into. One will notice, on the contrary, for how few deaths the chest is accountable in the same advanced period of life. Specific diseases of the viscera are rare. So is organic disease of the heart, though we should expect it to play an important part at such an altitude, with so much hard labour. But we must call to mind that the Avers people are particularly fortunate in inhabiting a flat land. We should also expect chronic alcoholism to be traced in these columns as a cause of death. We know that these mountaineers consume a great deal of spirits. They seem none the less to enjoy remarkable longevity, to keep their viscera free from disease, and when they die in the sixties or the seventies, or eighties, if drink has by that time told on them, it seems to do so by a

general constitutional effect that falls in with senile debility. So much for our first table, which follows immediately :—

AGE AT, AND CAUSES OF, DEATH AT AVERS FROM 1882 TO 1913.

	Cause of Death.	Age from: 1–10.	11–20.	21–30.	31–40.	41–50.	51–60.	61–70.	71–80.	81–90.	91–100.	Total.
1	Not stated	–	1	–	–	2	3	6	7	2	–	21
2	Senile debility	–	–	–	–	–	–	2	10	10	–	22
3	Diseases of childhood	10	3	–	–	–	–	–	–	–	–	13
4	Apoplectic fits	–	–	–	–	1	2	6	5	2	1	17
5	Inflammation of the lungs / Pulmonary emphysema	–	–	1	2	3	3	1	1	1	–	12
6	Accidental death	–	–	–	1	2	1	2	–	–	–	6
7	Dropsy	–	–	–	1	–	–	2	–	–	–	3
8	Rupture	–	–	–	1	1	–	–	–	–	–	2
9	Suicide	–	–	–	2	–	1	–	1	1	–	5
10	Diphtheria and whooping cough	–	–	–	–	–	–	–	–	–	–	0
11	Child-birth	–	–	2	1	1	–	–	–	–	–	4
12	Diseases of the kidneys and bladder	–	1	–	–	–	–	–	–	–	–	1
13	Influenza	–	–	–	–	–	–	2	–	–	–	2
14	Diseases of the heart	–	–	–	–	–	–	–	–	–	–	0
15	Diseases of the liver	–	–	–	1	–	–	–	–	–	–	1
16	Spinal complaints	–	–	1	–	–	–	–	–	–	–	1
17	Alcoholism	–	–	–	–	–	–	–	–	–	–	0
18	Zymotic diseases	–	–	–	–	–	–	–	–	–	–	0
19	Dysentery	–	–	–	–	–	–	–	–	–	–	0
20	Perityphlitis	–	–	1	–	–	–	–	–	–	–	1
21	Cancer	–	–	–	–	–	1	–	–	–	–	1
22	Wasting diseases and hæmorrhage of the lungs	–	1	–	–	–	–	–	–	–	–	1
23	Rheumatism of the joints	–	–	–	–	–	–	–	–	–	–	0
24	Troubles of the intestines	–	–	–	–	–	–	2	–	–	–	2
25	Mental disease	–	–	–	–	1	1	–	–	–	–	2
												117

2. The statistics of Inner Ferrera, where about fifty inhabitants dwell at an altitude ranging from that of Cresta-Avers down to 1,486 metres above sea level, should be added to the foregoing, as a complementary document. We could not take

AGE AT, AND CAUSES OF, DEATH AT INNER FERRERA FROM 1876 TO 1913.

	Cause of Death.	Age from: 1–10.	11–20.	21–30.	31–40.	41–50.	51–60.	61–70.	71–80.	81–90.	91–100.	Total.
1	Not stated . . .	–	–	2	1	1	1	4	5	–	–	14
2	Diseases of childhood .	9	–	–	–	–	–	–	–	–	–	9
3	Senile debility . .	–	–	–	–	–	1	–	1	3	–	5
4	Cancer	–	–	–	–	–	–	2	1	–	–	3
5	Accidental death . .	–	1	1	1	–	–	–	–	–	–	3
6	Inflammation of the lungs	–	1	–	–	–	–	1	–	–	–	2
7	Apoplectic fits . .	–	–	–	–	–	–	1	1	–	–	2
8	Suicide	–	–	–	–	–	–	1	–	–	–	1
9	Child-bed . . .	–	–	–	1	–	–	–	–	–	–	1
10	Diseases of the kidneys .	–	1	–	–	–	–	–	–	–	–	1
11	Meningitis . . .	–	1	–	–	–	–	–	–	–	–	1
12	Enlargement of the heart	–	1	–	–	–	–	–	–	–	–	1
												43

them further back than the year 1876, but this is quite enough to show in what measure they confirm the foregoing table. The latest decease was registered in 1910. The deaths come under twelve heads out of a possible twenty-five in the foregoing table.

It will be seen that the lesson to be derived from these additional figures is to the same effect as the preceding table. Nine deaths out of the fourteen whose cause was not ascertained, fall in old age, as do the two apoplectic fits and the case of inflammation of the lungs.

3. We shall now return to the statistics of Avers proper and consult the church books from 1825 to 1882. By so doing, we get a survey of fifty-seven years. But here we are face to face with a difficulty which we have already met in a lesser degree—the very large proportion of deaths whose cause is unaccounted for. From 1825 to 1882 we note 113 such entries. Fortunately, the age of each person at death is carefully given, and as the longevity figures are actually the best test of health, the damage done to our statistical record is not beyond remedy. We subjoin a table prepared accordingly. It will be found that out of a total of 113 deaths, 10 may be assigned to the ailments of childhood, while 57 fall to persons over 60 years old, and 24 to persons between 50 and 60. Now, if we refer to both preceding tables, it will be seen that there, too, senile debility (and apoplexy) are by far the most frequent causes of death from the age of 60 onwards.

Table of unstated Causes of Death in Avers from 1825 to 1882, according to Age.

Age.	1825–36.	1837–82.	Total.
0–10 . .	8	2	10
11–20 . .	1	4	5
21–30 . .	4	3	7
31–40 . .	2	3	5
41–50 . .	2	5	7
51–60 . .	17	7	24
61–70 . .	13	6	19
71–80 . .	22	5	27
81–90 . .	4	3	7
91–100 . .	1	1	2
	74	39	113

4. Having thus made out a case in favour of longevity, the causes of death from 1825 to 1882 should be given. We leave aside the total of deaths from unstated causes just dealt with. The period 1825 to 1882 extends over two generations, as against one only included in the later period already dealt with from the point of view of longevity, namely, 1892 to 1913.

Cause of Death.	1825-1882.	1883-1913.	Total.
Senility	81	22	113
Ailments of childhood / Congenital debility	62	13	75
Apoplexy	31	17	48
Pulmonary inflammation / ,, emphysema	32	12	44
Death by accident	26	6	32
Dropsy	22	3	25
Rupture	7	2	9
Suicide	4	5	9
Diphtheria and whooping cough (children only)	6	0	6
Child-birth / Puerperal fever	6	4	10
Diseases of the bladder and kidneys	4	1	5
Heart disease	2	0	2
Influenza	0	2	2
Complaints of the liver	1	1	2
Affection of the spine	0	1	1
Zymotic ailments	1	0	1
Dysentery	1	0	1
Perityphlitis	0	1	1
Cancer	12	1	13
Rheumatism of the joints	3	0	3
Intestinal disorders	13	2	15
Lunacy	0	2	2
Fatal termination of chronic affections	16	1	17

It should be borne in mind that during that period of three generations the population was gradually reduced by emigration and consequently the number of births fell to two-thirds of the original figure. There was no immigration.

The total of deaths during that period, if we now include deaths from unstated causes, would be 443 for 1825–1882, 116 for 1883–1913, giving a total of 560 by the end of the year 1913.

The causes of death by accident are instructive. One and all are characteristic of high Alp risks. They are avalanches, falling stones, falls over precipices, congelation.

The cases of inflammation of the lungs it seems impossible to describe further. Out of the fatal chronic affections, 4 deaths are attributed to hæmorrhage (ages 64, 54, 32, 30), 1 is ascribed to hectic fever (age 49), 2 to disease contracted abroad (21 and 19). Two of the cases are between 61 and 65, 3 in the fifties, 4 in the forties, 5 in the thirties, and 3 range from 19 to 21.

The three generations show 23 still-births. On comparing the last generation with the two preceding it, a marked improvement appears, allowing for the shorter period. The high proportion of deaths from apoplexy remains puzzling.

The Canton des Grisons numbers 120,000 inhabitants, and now contains thousands of lung patients imported from abroad. In the year 1909 there were recorded 22 deaths from diphtheria, 31 from whooping cough, 12 from eruptive diseases, none from typhoid, none from erysipelas, 177 from pulmonary phthisis, 64 from other tubercular complaints, 130 from pneumonia.

In the Canton du Valais, which is analogous in every respect —altitude, climate, occupations of the natives, imported patients, population, etc.—we find for the same year 1909, 32 deaths from eruptive diseases, 23 from diphtheria, 10 from whooping cough, 4 from erysipelas, 22 from typhoid, 147 from pulmonary phthisis, 63 from other tubercular diseases, 175 from pneumonia.

For the whole of Switzerland, numbering little under four million inhabitants, including permanently very many patients of foreign origin, and a large floating population of health-seekers, we find, in 1909 :—

Congenital debility	3,920
Small pox	3
Scarlatina	170
Whooping cough	846
Typhoid	113
Scrofulosis	54
Infantile enteritis	2,533
Uncertain diagnosis	836

Senile debility	2,313
Measles	373
Diphtheria	580
Erysipelas	114
Puerperal fever	238
Pulmonary tuberculosis	6,008
Other tubercular diseases	2,504
Pneumonia, croup	5,403
Carcinoma	4,443
No medical certificate	1,746

The latest statistics officially elaborated and published before the outbreak of war applied to the year 1911. They showed 8,980 attested deaths from tubercular disease, 4,253 in the case of men and 4,727 in the case of women. Pulmonary tuberculosis accounts in this total for 5,872 deaths, 2,769 men and 3,103 women. It cannot be said that the aggregate of large towns contributed more victims to the death roll of tuberculosis than the aggregate of country districts.

From 1884 to 1912 the progress in general health, gauged by the death-rate obtaining in fourteen principal diseases, shows a marked and steady improvement in ten: small pox, measles, scarlatina, diphtheria and croup, whooping cough, erysipelas, typhoid (almost extinct), puerperal fever, organic heart troubles, infantile enteritis. On the other hand, the improvement is slight in the items showing the highest mortality figures: pulmonary tuberculosis, other tubercular affections, acute disease of the respiratory organs, carcinoma and sarcoma.

PART III

SUNLIGHT AND SUN HEAT

PART III

CHAPTER I

The sun as a sanitary agent—Watered flatlands—The sea and seaside climate—The climate of altitude—A specimen day of bad winter weather—The three typical winter months.

Just as our first lecture was on cold, and the second on air, we shall discuss in the third the curative effect of sunlight upon those who go to an altitude for sport and pleasure, and also upon that extremely pathetic class: those who undergo a mountain-air treatment for the cure of disease.

Sunlight is the most characteristic feature of altitude; more characteristic than cold, more characteristic than pure air. Those who go to the mountains in summer may have a preference for shade, as in summer the temperature of the air is comparatively high, but the winter sportsman is a sun-worshipper, while sufferers from tubercular complaints seek at all seasons the sunlight. To them it is not only a comforter but a healer.

Most people believe that the configuration of mountain ranges causes the sun to rise late and set early. This is the case in the deep valleys to which summer tourists are wont to flock. But the Alps consist really of terraces rising above a forest belt. Every Alpine grazing is a sunny terrace. There are thousands of these, all waiting to confer untold blessings upon mankind, if we would but forsake our gregarious instincts and dwell in detached chalets, instead of inhabiting continuous rows of hotel rooms opening upon endless passages, and generally reeking with the dampness of woodland, meadowland and lakeland.

The cure of tubercular disease by means of sunlight is a new science.

The sun is the agent. It operates through those chemical and physical peculiarities which sunbeams acquire or preserve as a consequence of altitude. At an altitude of 6,000 feet in the Alps flesh and open sores exposed to the sun do not undergo septic processes. A large proportion of the solar light at those heights has not yet been intercepted or absorbed by the thick

atmosphere subsisting at the lower levels. The so-called violet and ultra-violet rays are still in full force, and this is available for therapeutic effects.

Those natural rays may be used to cure pulmonary tuberculosis, this being the mountain-air cure of disease without sun specialisation. Or else the sun rays may be expressly employed by exposing to them such diseased parts of the human body—tubercular bone or tissue—as used to be reserved formerly for surgical treatment. Time and sun are the watchwords of the new school.

The sun cure shows boys and girls in all stages of disease being gradually restored to health and recovering the use of their limbs by the unaided influence of the Alpine sun.

The most striking feature of this cure is the paradoxical association it shows of nudity in the snows of winter with the rays of a burning sun as curative agent. Then boys and girls, to look at, are as the tribes of niggers in Equatorial Africa, doing civilised work out of doors under the direction of missionaries, pictures which are a familiar feature in Sunday-school magazines.

The colour of the skin turns to a ruddy, healthy brown under the impact of the sun rays, the open tubercular sores dry up and the diseased tissue crumbles off, while a new cell activity sets in. Thus the hygienic concomitants of altitude might be substitutes for the medicinal and surgical treatment of tubercular diseases.

Mountain air may be a prophylactic, may be a palliative, or may be actively curative. The open-air treatment affects the inner organs too. Specialised solar treatment may be applied to the skin and to exposed diseased centres alike.

To trace the history of the sun as a sanitary agent we should have to go back to the most primary instinct of primeval man. The ancients—who, for us, are inhabitants of the warmer temperate zone of western Asia and Europe, all along both Mediterranean borders, from the Atlantic to Syria and Egypt, and across Syria to the valley of the Euphrates and Tigris on to Persia—were genuine sun worshippers as well as great bathers, so far as the well-being of their bodies was concerned, and reserved on their houses spaces, gardens and terraces, to which we may ascribe a large share in the maintenance of domestic hygiene.

Unfortunately, it must be confessed that the outdoor life and sun baths of the pre-Christian races became connected in the opinion of Christian zealots with unholy living. The washing of the human skin with warm water and scented oils and its exposure in loose and light garments to the embrace of the breeze and to the kisses of the sun, were abandoned in an age when subterranean places were sought out for worship and the care of the body was looked upon as an opportunity which the Devil would seize to do some evil work injurious to the soul. There are still numbers of good and decent folk who look upon the air as an enemy and seek health in protection from it. These are the people who would apply to the maintenance of health certain rules which are good for the care of patients whose health has so run down or whose conditions of disease are of such a description that it would be cruel to ask them to lead the best ordinary life, that appointed for the ordinary man in good health.

People live either in the flatlands or on the seaside or among the hills. Each of these three stations, however vast it may be, is characterised with reference to the other two in some manner susceptible of close definition. We have not yet described those three climates synoptically.

I. Watered Flatlands.

1. These are open to all the winds, as they are not surrounded within appreciable distance by a screen of heights. Consequently wind-free days are few in number.

2. The variations of temperature from one season to the opposite season are very great—hot summers, rough, cold winters.

3. Measured by the hygrometer, the quantity of vapour suspended in flatland atmosphere is great and approaches the point of absolute saturation.

4. There results from this great dampness of the air an almost constant distillation, which ranges from a light, transparent, blue veil of vapour to the most condensed and impenetrable mist.

5. In direct proportion to condensation there is a reduction in the illuminating power of the sun and in the intensity of its chemical rays. We have seen that sun intensity—not air

heat—is always less in the plain than in the mountains. The difference is more and more unfavourable to the plain as the season advances from summer to winter, when the difference reaches its maximum.

6. The air of flatlands is not free from objection with reference to its bacteriological contents. Traffic and movement of every kind on streets and roads, railways, etc., produce dust, the greater dampness of the air helps to fix the bacteria. The bactericide activity of light is considerably reduced by the moisture or by the dust itself in suspension in the air. The flatlands are therefore, with the help of the wind, just the places for the dissemination, multiplication and preservation of micro-organisms. As soon as we move from the flatland into wooded or slightly hilly country these inconveniences are less serious. The air may be unobjectionable, dwelling-places may be screened from the wind, but the roughness and cheerlessness of the winter remains as well as the great moisture of the air and a considerable formation of mist resulting from moisture. This is particularly characteristic of the climate in the British Isles.

II. Sea and Seaside Climate.

There are few climates whose properties are so exactly definable as the climate of the sea. It would be difficult to find an influence put forth by nature so general, so constant and so potent as that which arises from the proximity of those stupendous masses of salt water. The great cleanliness of sea air is fully confirmed by bacteriological investigation. The practically complete elimination of dust (but *on* the sea only), the great frequency of the winds blowing regularly over the surface of the ocean, are contrary to the production of micro-organisms and scatter far from the centres of production those that may be given birth to. The light of the sun has free play on the ocean, and its operative power derives considerable increment from the gigantic reflecting mirror provided by the surface of the water. The sun, as one sees, is an essential curative element that has free play on the sea, the atmosphere of which contains also salt in great quantity—as much as from two to five-thousandths of a gramme per cubic metre of air. There are also in sea water mineral elements which are all transferred to the air with the salt, particularly iodine, the quantity of which

is twelve times larger in sea air than in a midland atmosphere, and the same holds good of ozone, bromine and silicic acid.

The purely meteorological elements of the sea and of seaside climate are of great significance. The sea is an enormous storehouse for heat. There, in contradistinction from the earth, which quickly absorbs heat and gives it out again just as promptly, the difference of temperature between night and day and the variations in the course of the day are slight, and the contrast between opposite seasons is softened. Barometric pressure does not show much variation. Sea air is, comparatively speaking, very damp, not only on account of the frequent rainfalls, which are also generally heavy, but principally on account of the large quantity of invisible vapour it carries. Winds, too, are frequent, from the light cooling sea breeze to the violent air-cleansing winds that blow over land and sea.

There subsists, however, no general bond of analogy between all sea climates or seaside climates, as the foregoing factors may be mixed in the most varying proportions. The Mediterranean border, the Atlantic border, the North Sea border, for instance, possess climates that are not interchangeable. The Mediterranean climate gives prominence to the following features :—

Extreme mildness (average winter temperature plus 10° C.).

Great intensity of light, resulting from comparative dryness, and great transparency of the air.

The persistency of insolation.

The fewness of rainy days concentrated upon short periods in spring and autumn.

III. The Climate of Altitude.

This is the climate whose unity is most striking and interests us most in this lecture. We shall insist on its characteristics more completely than when summing up the sea and flatland climates.

1. The air pressure is slight.

2. Winds are not frequent. Spots well protected from the wind are very easily found in a mountainous land. This applies particularly to open slopes and funnel-shaped inclines facing south. These give absolute protection against the north wind. No sea-borne, bitter east wind.

3. Great dryness of the air.

4. Slight and transient obnubilation. As soon as a height of from 1,200 to 1,500 metres is reached, obnubilation becomes steadily rarer. The inhabitants often bask in winter for months in the most magnificent sunshine, while at their feet, at an altitude of about 800 to 900 metres, spreads a thick screen of mist, wrapping in cold and darkness the land lying underneath.

5. Long spells of rain, no rare occurrences on flatlands, are quite exceptional at noteworthy altitudes.

6. The comparative immunity from obnubilation prolongs considerably the duration of sunshine. The difference strikes one particularly when one's attention is drawn to the winter conditions. Our readers already know that in the four months of November, December, January and February, the reckoning up of the hours of sunshine gives in St. Moritz (1,856 metres) a total which is twice as large as in Zurich (411 metres). Yet there are gloomy days. Here is the record, in the figures of the Central Meteorological Office at Zurich, of a dull winter's day, taken at twenty-nine stations, ranging from the altitude of 276 metres to 1,856 metres. The date is January 14th, 1914, at eight o'clock in the morning, which, in Central European time, means three-quarters of an hour before actual sunshine at the higher altitudes in the depth of winter. On the next morning the official report ran that it was snowing on both sides of the Alps, without any notable rise in temperature, which was very low, down to — 20° C. in western central Europe. The cold was not quite so sharp in the highest winter stations. The pressure was 760 millimetres at Zurich, 770 in London.

People accustomed to English weather charts on bad winter days will realise on reading this first table that they have to do here with a record of bad weather whose characteristic note is uniformly severe weather under conditions of intense cold and windlessness. Numbers 5, 6, and 17 show starry heavens before dawn, which led to the note "sunny in places" for that day in the January table further on. The snowfall of the ensuing night broke up into the locally diversified report appearing in the same January table for the 15th. Such a chart would be quite exceptional in the British Isles, even limited to Scotland.

METEOROLOGICAL TABLE, JANUARY 14TH, 1914.

No.	Altitude in Metres.	Stations.	Temperature. Centigrade.	Weather.	Depth of Snow on Ground.
1	1,360	Adelboden.	−17	Overcast.	0·90 centimetres.
2	1,444	Andermatt.	−10	Snowing.	More than 1 metre.
3	1,856	Arosa.	−12	Overcast.	,, ,, ,,
4	991	Les Avants.	−12	Snowing.	0·35 centimetres.
5	1,052	Caux.	−13	No clouds, very still.	0·55 ,,
6	1,060	Champéry.	−12	No clouds, very still.	0·35 ,,
7	978	Château-d'Oex.	−14	Cloudy.	0·35 ,,
8	1,561	Davos.	−17	Overcast.	More than 1 metre.
9	1,019	Engelberg.	−14	,,	0·90 centimetres.
10	1,050	Grindelwald.	−16	Misty.	0·90 ,,
11	1,053	Ostaad.	−13	Overcast.	0·45 ,,
12	1,169	Kandersteg.	−14	,,	0·70 ,,
13	1,190	Klosters.	−16	Misty.	More than 1 metre.
14	1,477	Lenzerheide.	−16	,,	0·90 centimetre.
15	1,411	Loëche-les-Bains.	−14	Overcast.	0·45 ,,
16	276	Lugano.	− 2	Snowing.	0·05 ,,
17	{1,680	Montana-Vermala.	−14	No clouds, very still.	0·45 ,,
	538	Sierre (No snow).			
18	376	Montreux.	− 7	Overcast.	0·05 ,,
19	1,250	Mont-Soleil s. St. Im.	−15	,,	0·45 ,,
20	1,650	Mürren.	−18	Misty.	More than 1 metre.
21	1,008	Le Pont.	−12	Overcast.	0·55 centimetre.
22	1,440	Righi-Kaltbad.	−16	,,	More than 1 metre.
23	1,187	Ste. Croix Rasses.	−17	Misty.	0·45 centimetre.
24	1,826	St. Moritz.	−15	Snow.	0·45 ,,
25	1,275	Villars-Chesières.	−14	,,	0·70 ,,
26	1,130	Waldhaus-Flims.	−13	Overcast.	More than 1 metre.
27	1,300	Weissenstein.	−15	Cloudy.	0·65 ,,
28	1,279	Wengen.	−15	Overcast.	0·70 ,,
29	945	Zweisimmen.	−13	,,	0·35 ,,
30	1,043	St. Cergue (Nyon).	−17	,,	0·45 ,,

It is indeed in winter that Alpine weather differs most clearly from English weather, as will appear from the following tables covering the months of December, 1913, January and February, 1914. March will generally be found to be of the same quality.

Throughout this book, and in every respect, we have abstained from quoting the most recent figures, owing to the sweeping confusion and irregularity in civil life entailed by the War.

Weather in the Swiss Alps and Jura, Winter Months, December, 1913.

Date.	Temperature at 8 A.M. (before sunrise) = 7 A.M. in London, with sunrise at 8.	Weather at Sunrise. Sun, Rain or Wind.	State of Ground. Lying Snow in Centimetres. (As a rule no snow at Lugano or Montreux.)
3	From 0° C. to − 6° C.	Still, sunny. . . .	From 5 c. to 55 c.
4	„ 0° C. to − 6° C.	Still, sunny (rain at Lugano).	„ 5 c. to 55 c.
5	„ −1° C. to − 7° C.	Snowy, overcast, or fine .	„ 5 c. to 55 c.
6	„ 0° C. to − 5° C.	Snowy, overcast (rain at Ch. d'Oex, Montreux temp. + 5° C.).	Melting snow, rain elsewhere. Thickness of layer: 5 c. to 55 c.
7	„ 0° C. to − 5° C. (Lug. + 5° C. Mon. + 5° C.)	Snowy, rainy . . .	From 5 c. to 55 c.
8	„ −2° C. to −11° C. (Mon. + 2° C.)	Still, sunny, or cloudy .	„ 5 c. to 88 c.
9	„ −1° C. to −13° C. (Lug. + 1° C. Mon. + 1° C.)	Still, sunny	„ 5 c. to 90 c.
10	„ 0° C. to − 5° C. (Mon. + 4° C. Lug. + 2° C.)	Cloudy, thaw . . .	„ 5 c. to 70 c.
11	„ 0° C. to − 5°C. (Lug. + 13° C. Mon. + 6° C.)	Snowy, overcast (Lugano, sun and wind).	„ 5 c. to 90 c.
12	„ 0° C. to − 7° C. (Mon. + 7° C.)	Foggy, overcast, fine .	„ 5 c. to 100 c.
13	„ 0° C. to −12° C.	Still, sunny, cloudy . .	„ 5 c. to 100 c.
14	„ 0° C. to −12° C. (Lug. + 3° C. Mon. + 3° C.)	Still, sunny, cloudy . .	„ 5 c. to 100 c.
15	„ 0° C. to − 8° C. (Lug. + 13° C. Mon. + 3° C.)	Still, sunny, cloudy, snowy (Lugano, windy).	„ 5 c. to 100 c.
16	„ 0° C. to − 8° C. (Lug. + 4° C. Mon. + 2° C.)	Still, sunny, cloudy, snowy.	„ 5 c. to 100 c.
17	„ −2° C. to −12° C. (Lug. + 3° C. Mon. + 3° C.)	Still, sunny, cloudy, snowy.	„ 5 c. to 100 c.
18	„ −2° C. to −10° C. (Lug. + 2° C. Mon. + 2° C.)	Still, sunny, overcast, snowy.	„ 4 c. to 100 c.
19	„ −4° C. to −15° C. (Lug. + 4° C.)	Still, sunny, overcast .	„ 4 c. to 100 c.
20	„ 0° C. to −13° C. (Mon. + 2° C.)	Still, (Righi, snowstorm), sunny elsewhere.	„ 2 c. to 100 c.
21	„ −2° C. to −13° C. (Lug. + 1° C.)	Still, sunny. . . .	„ 5 c. to 100 c.
22	„ −1° C. to − 13° C. (Lug. + 1° C.)	Still, sunny everywhere .	„ 2 c. to 100 c.
23	„ −1° C. to −12° C. (Lug. + 1° C.)	Still, sunny everywhere .	„ 2 c. to 100 c.
24	„ −2° C. to −14° C. (Lug. + 2° C.	Still, sunny everywhere .	„ 2 c. to 100 c.
25	„ −2° C. to −14° C.	Sunny, breezy . . .	„ 2 c. to 100 c.
26	„ 0° C. to −15° C. (Mon. + 1° C. Lug. + 1° C.)	Still, sunny, cloudy . .	„ 2 c. to 100 c.
27	„ 0° C. to − 8° C. (Lug. + 1° C.)	Still, sunny . . .	„ 2 c. to 100 c.
28	„ −2° C. to − 8° C.	Still, cloudy, breezy . .	„ 15 c. to 100 c.
29	„ 0° C. to −19° C. (Mon. + 1° C.)	Snowy, misty, cloudy .	„ 15 c. to 100 c.
30	„ −1° C. to −18° C. (Lug. + 3° C.)	Snowy, cloudy, sunny .	„ 25 c. to 100 c.
31	„ −4° C. to −18° C. (Lug. + 2° C.)	Snowy, overcast, sunny .	„ 25 c. to 100 c.

Weather in the Swiss Alps and Jura, Winter Months, January, 1914.

Date.	Temperature at 8 A.M. (before sunrise) = 7 A.M. in London, with sunrise at 8.	Weather at Sunrise. Sun, Rain, or Wind	State of Ground. Lying Snow in Centimetres. (As a rule no snow at Lugano or Montreux.)
1	From −5° C. to −22° C.	Still, sunny, misty	From 25 c. to 100 c.
2	,, −5° C. to −23° C.	Still, sunny	,, 25 c. to 100 c. (Montreux 5 c., Lugano 0 c.)
3	,, −2° C. to −13° C.	Cloudy, sunny, snowy	From 25 c. to 100 c. (Montreux } Lugano } 0 c.)
4	,, −1° C. to −16° C.	Still, overcast, sunny	From 25 c. to 100 c.
5	,, −1° C. to −16° C.	Still, sunny, cloudy	,, 25 c. to 100 c. (Montreux } Lugano } 0 c.)
6	,, −1° C. to −15° C. (Lug. + 2° C.)	Still, sunny, snowy	From 25 c. to 100 c. (Montreux } Lugano } 0 c.)
7	,, −1° C. to −11° C. (Lug. + 2° C.)	Snowy, windy, overcast	From 35 c. to 100 c. (Montreux 5 c., Lugano 0 c.)
8	,, −1° C. to −12° C. (Lug. + 3° C.)	Still, cloudy, sunny	From 35 c. to 100 c. (Montreux 5 c., Lugano 0. c.)
9	,, −1° C. to − 8° C. (Lug. + 2° C.)	Snowy, overcast, sunny	From 45 c. to 100 c. (Montreux 5 c., Lugano 0 c.)
10	,, 0° C. to − 2° C. (Lug. + 8° C.)	Overcast, misty, snowy (Lugano, sunny).	From 35 c. to 100 c. (Montreux 5 c.)
11	,, 0° C. to − 4° C.	Overcast, snowy (Lugano, sunny).	From 35 c. to 100 c.
12	,, −1° C. to −13° C.	Snowy, overcast	,, 35 c. to 100 c. (Montreux } Lugano } 5 c.)
13	,, −2° C. to −16° C.	Still, sunny, overcast	From 35 c. to 100 c. (Montreux } Lugano } 5 c.)
14	,, −2° C. to −18° C.	Still, overcast, snowy, sunny in places.	From 35 c. to 100 c. (Lugano } Montreux } 5 c.)
15	,, −1° C. to −16° C.	Still, sunny, overcast, snowy.	From 35 c. to 100 c. (Lugano } Montreux } 5 c.)
16	,, −8° C. to −18° C. (Lug. + 1° C.)	Still, sunny, overcast	From 35 c. to 100 c.
17	,, 0° C. to −15° C.	Still, sunny, cloudy	,, 35 c. to 100 c. (Lugano } Montreux } 5 c.)
18	,, −1° C. to −18° C.	Still, sunny, overcast	From 35 c. to 100 c.
19	,, −3° C. to −18° C. (Lug. + 1° C.)	Still, sunny, overcast	,, 35 c. to 100 c. (Lugano } Montreux } 5 c.)
20	,, 0° C. to −18° C. (Lug. + 1° C.)	Sunny, still	From 35 c. to 100 c.
21	,, −1° C. to −14° C.	Snowy, cloudy, sunny	,, 25 c. to 100 c. (Montreux 5 c.)
22	,, −3° C. to −18° C.	Snowy, sunny, cloudy	From 20 c. to 100 c.
23	,, −3° C. to −18° C.	Still, sunny	,, 25 c. to 100 c. (Montreux 5 c., Lugano 0 c.)
24	,, −4° C. to −16° C.	Still, sunny	From 25 c. to 100 c.
25	,, −1° C. to −18° C. (Mon. + 4° C.)	Still, sunny	,, 35 c. to 100 c. (Les Avants 2 c.)
26	,, −2° C. to −15° C.	Still, sunny	From 25 c. to 100 c.
27	,, −1° C. to −14° C. (Lug. + 1° C.)	Still, sunny, cloudy	,, 25 c. to 100 c.
28	,, −3° C. to −12° C. (Lug. + 4° C. Mon. + 1° C.)	Snowy, sunny, overcast	,, 25 c. to 100 c. (Montreux 5 c.)
29	,, −3° C. to −17° C.	Still, sunny	From 25 c. to 100 c.
30	,, −3° C. to −21° C.	Still, sunny	,, 25 c. to 100 c.
31	,, −2° C. to −19° C.	Still, sunny	,, 25 c. to 100 c.

Weather in the Swiss Alps and Jura, Winter Months, February, 1914.

Date.	Temperature at 8 A.M. (before sunrise) = 7 A.M. in London. with sunrise at 7.19.	Weather at Sunrise. Sun, Rain, or Wind.	State of Ground. Lying Snow in Centimetres. (As a rule no snow at Lugano or Montreux.)
1	From 0° C. to −12° C. . . .	Still, sunny . . .	From 25 c. to 100 c.
2	,, 0° C. to −12° C. . . .	Still, sunny	,, 25 c. to 100 c.
3	,, 0° C. to −14° C. . . .	Still, sunny	,, 25 c. to 100 c.
4	,, −1° C. to −20° C. . . .	Still, sunny	,, 25 c. to 100 c.
5	,, −1° C. to −17° C. . . .	Still, sunny (Montreux overcast).	,, 25 c. to 100 c.
6	,, −1° C. to −12° C. . . .	Still, sunny (Montreux overcast).	,, 25 c. to 100 c.
7	,, −1° C. to −11° C. . . .	Still, sunny (Montreux misty).	,, 25 c. to 100 c.
8	,, −1° C. to −11° C. . . .	Still, sunny	,, 25 c. to 100 c.
9	,, 0° C. to −12° C. . . .	Still, sunny	,, 25 c. to 100 c.
10	,, 0° C. to −11° C. . . .	Still, sunny	,, 5 c. to 100 c.
11	,, −1° C. to −11° C. (Mon. + 2° C.)	Still, sunny	,, 5 c. to 100 c.
12	,, 0° C. to − 7° C. . . .	Still, sunny, cloudy . .	,, 5 c. to 100 c.
13	,, 0° C. to − 5° C. . . .	Still, snowy, overcast, sunny (Lugano, rain) .	,, 5 c. to 100 c.
14	,, −2° C. to −11° C. (Lug. + 3° C. Mon. + 2° C.)	Still, sunny, overcast .	,, 15 c. to 100 c.
15	,, −1° C. to −11° C. (Lug. + 3° C. Mon. + 2° C.)	Still, sunny, cloudy . .	,, 15 c. to 100 c.
16	,, 0° C. to − 4° C. (Mon. + 5° C. Lug. + 2° C.)	Sunny, cloudy . . .	,, 5 c. to 100 c.
17	,, + 5° C. to − 4° C. . . .	Cloudy, sunny . . .	,, 5 c. to 100 c.
18	,, + 5° C. to − 7° C. . . .	Still, sunny	,, 5 c. to 100 c.
19	,, 0° C. to −12° C. (Lug. + 4° C. Mon. + 3° C.)	Windy, snowy, cloudy .	,, 15 c. to 100 c.
20	,, + 5° C. to − 8° C. . . .	Still, sunny, snowy . .	,, 15 c. to 100 c.
21	,, 0° C. to − 6° C. (Lug. + 4° C. Mon. + 3° C.)	Sunny, cloudy . .	,, 15 c. to 100 c.
22	,, 0° C. to − 9° C. (Lug. + 6° C. Mon. + 5° C.)	Still, overcast, misty .	,, 15 c. to 100 c.
23	,, 0° C. to − 5° C. (Lug. + 8° C. Mon. + 2° C.)	Snowy, stormy, overcast .	,, 15 c. to 100 c.
24	,, −1° C. to − 9° C. (Lug. + 1° C. Mon. + 1° C.)	Still, sunny	,, 10 c. to 100 c.
25	,, 0° C. to − 7° C. . . .	Sunny, cloudy, snowy .	,, 10 c. to 100 c.
26	,, 0° C. to − 7° C. (Lug. + 5° C. Mon. + 5° C.)	Overcast, snowy, misty (Lugano, rain).	,, 10 c. to 100 c.
27	,, 0° C. to − 9° C. (Lug. + 6° C. Mon. + 5° C.)	Still, overcast, misty .	,, 15 c. to 100 c.
28	,, 0° C. to − 9° C. (Lug. + 7° C. Mon. + 4° C.)	Still, sunny, cloudy . .	,, 5 c. to 100 c.

The Jura climate differs from the Alpine climate in that it is quite uniform, colder in winter, wind-swept, keen and easterly in the English sense of the word.

CHAPTER II

The medical properties of sunlight—Sunburn and pigment—The four aspects of the tubercular taint—The sun cure for "surgical" tuberculosis—Its application to children—Nude exposure—Winter hotels at altitudes—The "Alpine" internment and treatment of war patients.

THE perusal of the foregoing tables and earlier chapters shows that in the Swiss Alps the climate in winter is at our latitudes a climate of *superlatives:* the greatest cold and the strongest light (for the season); the greatest heat and height (for residence); the driest and purest air. Sunlight and solar heat are the outstanding features, and altitude is the common basis of all those superlative points.

That our knowledge of the action of sunlight is very scanty should not be concealed. Our means of research do not enable us yet to fathom and to comprehend all the photo-chemical and actino-electrical phenomena which are induced in the living cells and in the organic tissues of our bodies by the diverse sorts of solar radiations with which we are conversant in physics.

There is another difficulty: this is associated with all new healing methods, perhaps more with heliotherapy than many others. It is the trouble which we experience in severing the true bearing of the facts from the enthusiastic affirmations of some and from the systematic denials of others. As in other respects, time here may be trusted to bring along correct answers to the problems with which we are still confronted.

The rays of the *spectrum* fall into three groups. There are those whose properties give heat; there are those whose functions impart light, and there are those which we call chemical rays, because our unaided senses cannot pronounce upon their nature. A substance of the material order, such as our bodies, may be warmed by the rays of the sun; it may be bathed in light by the sun; it may be penetrated by rays which we can neither see nor feel. These may modify the texture of the body; they may alter its chemical composition and affect its electric condition.

The purer, the drier, the thinner the air, the more intense the sunshine. In these respects the sunshine of altitudes possesses an indisputable superiority over that of the lowlands. However, fairness demands that we should repeat how much seaborders too may claim a share in those qualities. The surface of the sea, the sand of the beaches, reflect light ; the air is not contaminated by them. The Alpine climate and the maritime climate have at all times been conjoined in medical treatises, from that of Dr. William Marcet onwards, and recommended with equal plausibility in the case of like diseases.

Most authorities admit that the stimulating action of sunshine upon the life of animate beings is perceived by them through their nervous systems. But the germ-killing efficacy of sunshine is a direct effect proceeding from the sun in which our nervous *sensorium* has no say. Our bodies are as gardens in which germs fructify. Some of those germs are weeds that flourish in the dark. When exposed to sunlight they perish. The weeding out of our gardens is the work of those invisible, imperceptible gardeners, the chemical rays, sent out by the sun on that particular job.

Most pathogenic microbes are destroyed by sunlight. Among these the bacillus of tuberculosis, which most interests us to-day, is particularly susceptive of the action of the sun. Spread out in thin layers, say, like caviare crushed upon a plate, and exposed to sunlight, those bacilli become inoperative in a few hours. They are sterilised or become dormant. And this effect of the sun extends to some other microbes as well. The inflammatory lung affections of tubercular patients, to quote an instance germane to our subject, show less febrile acuteness at high altitudes than in the nether air which the sun does not sweep so clean.

The penetrative power of sunlight is its essential curative faculty. How far sunshine may enter our houses—and how much—depends on the depth of our rooms and on the number of our windows. How far, and how much, sunshine may penetrate into our bodies depends on the tissues to be traversed, but also on the rays themselves. Some tissues are more penetrable than others, some rays are more blunt than others. Press the blood out of the lobe of your ear, the rays will all pass

through it. But if the blood is allowed to return, then the red lines and the yellow lines of the *spectrum* will alone shine through. The ultra-violet rays are retained by the blood. Those furthest from the most extreme among these are the most useful; their chemical force is spent in the blood.

A sensitised photographic plate will receive impressions from ordinary white light sun rays which have travelled through areas of tissue six inches thick. This brings internal tubercular troubles within the scope of heliotherapy.

If we may introduce here some terms borrowed from the vocabulary of a physician—adenitis, osteitis, arthritis, peritonitis, cystitis, nephritis, enteritis, spondylitis, hip-bone disease, etc.—we see how many internal complaints come within the curative reach of the sun, thanks to the ability of the chemical rays to get behind the tissues, so to say, and into the bacteria "nodules." What one may be doubtful about is whether such recoveries are due only to the bactericide action of direct sunlight upon the tubercular lesion—or pocket—or whether exposure to the sun does not also produce indirect healing effects upon the tubercular sore, by means of the general stimulation of the organism of which we have seen that our nervous system is made aware.

Before passing on to the study of the effects of sunlight upon the human organism, I must mention in a few words a phenomenon which has raised many controversies and the significance of which is not yet quite made out: I mean the pigment of the skin.

We all know what sunburn is: a temporary heated condition of the skin owing to exceptional—not habitual—exposure to the sun. If sun exposure is prolonged, or if sun exposure is frequently renewed, the irritation and redness of the skin pass away and a permanent ruddy tan remains instead. This is pigment. The process is that of pigmentation.

What the colouring matter is we do not know. But it is quite unnecessary, in order to lead up to it, to court sunburn. The latter is an irritation which every reasonable person would rather avoid, while pigmentation is the result of skin stimulation by solar action, an extremely agreeable and pleasing sensation indeed.

Some authorities attribute pigmentation to the colouring matter of the blood exposed to solar action at the extremity of the capillary vessels. Others think that hæmoglobin is not the exclusive origin of the process. For an explanation they look to nuclei and protoplasma.

The composition of pigment has not been accurately gauged so far. Is it a carbon deposit in the cells, ensuing upon oxidation of the blood? Is it the physiological reflex of exposure to ultra-violet rays?

All we know is that it is a natural impression made upon our skin when we sun our bare bodies methodically at an altitude; that it is a pleasant and agreeable pastime, but one to be indulged in slowly and gradually, as irritation of one's white skin is quite objectionable; that it keeps up a high temperature in the cutaneous vessels and tissues; that, as a protection against cold, it is more liberally granted to certain constitutions than to others. The fair complexioned do not take on the pigment so well as the dark complexioned. Tuberculosis is certainly more frequent and more tenacious among the fair than among the dark-skinned Europeans. The opposite would seem to be the case with cancer. The point would, therefore, appear to be to give to those affected with tuberculosis the natural powers of resistance which belong to the dark complexioned, and which deliberate pigmentation may restore to the fair and enhance in every case.

To sum up, the therapeutic action of sunlight takes two directions which converge towards one and the same end: the destruction of pathogenic germs, the general stimulation of the human organism.

There are all sorts of suns, because there are all sorts of atmospheric, climatic and meteoric conditions in the world. The best sun shines on the sea and on the mountains.

We have to distinguish, for treatment at an altitude by sunlight, between:—

First. Latent tuberculosis—which term no doubt covers rheumatic affections of the joints.

Second. Surgical tuberculosis.

Third. Visceral—but not pulmonary—tuberculosis.

Fourth. Pulmonary tuberculosis.

The best results are attained in the treatment of surgical tuberculosis. The seat of the disease being then local, circumscribed and exactly definable, it falls in the category of certain purulent wounds which may be exposed to the air and sunlight after being treated with suitable ointment, in which case the healing is very rapid and the drying out of the surface most noticeable.

In the case of surgical tuberculosis the following features may be observed while the cure proceeds. There is no question of applying the knife :—

First. The bacteria are starved out of existence by the sun.

Second. Sclerosis, that is the drying up of the diseased tissue, intervenes next.

Third. Sunlight acts as a solvent to pain all along.

After a time the patients are as black as ~~niggers~~, the bacillary sores are closed and scarred over, the scab comes off in scales, the white tumours are dried, the secretions stop or are resorbed, a rapid, healthy granulation and epidermisation takes place.

" Insolation " should not be too violent at first ; the head, the heart, the lungs should be screened off from the sun for a time, as organs liable to congestion.

Children are the best subjects, for obvious reasons ; the recuperative powers of a growing organism favour their recovery and blood spitting is rare with them, so that the desiccation of pulmonary lesions may run quite an undisturbed and regular course.

Heliotherapic treatment has to be applied in suitable climates and in the right seasons. It requires special arrangements in the way of housing and bedding, and a strict supervision of a physician well versed in the methods.

Hitherto heliotherapic treatment of pulmonary tuberculosis has been attempted mainly at an altitude and by the seaside. Yet it may be carried on with fair chances of success wherever proper installations and competent direction are available.

Yet high altitudes appear preferable, if for no other reason than because light is there endowed *naturally* with those qualities that accompany radiations when more intense than on lowlands. Besides, the climatic conditions obtaining at

places elevated in the air make sun baths effective in any and every season, which is not the case on the seaside and, generally speaking, in the depths of the atmosphere. The various combinations of warmth and damp the world over, and whether indoors or in the open, so long as the human body remains the home of bacilli, should be accounted among the sliest enemies of mankind.

We have said with how much moderation and careful graduation one should set about the insolation of the human body. At first the body should be exposed in parts only for five or ten minutes at a time, and then the time-exposure may be gradually lengthened and the stage of general insolation may be reached after a few days. The feet and calves are taken first, then the legs and knees, both front and back, of course, in every case. Then the thighs, then the back of the trunk, then the front of the trunk, but the chest last of all, because the lungs and the heart in such patients as are " congestive " should be the object of particular care. The need for protecting the head, sensitive eyes and tender lips of newcomers need not be enlarged upon. The length of the total sun bath may vary from twenty minutes to the whole day. The longest possible exposure seems to give the best results in pronounced " surgical " cases. The reader need not be reminded here that " surgical " cases with us are those which used formerly to be surgically treated, the surgeon being now totally superseded by the physician in the Alpine sanatoria.

There is exposure to the morning sun, exposure to the mid-day sun and exposure to the afternoon sun. The nature and degree of the disease under treatment, the varying intensity of sunlight according to weather, the transparency of the air, the general response of the patient to sunlight as well as the local reaction of his wound, have to be adjusted or allowed for in each individual case.

A sun bath is termed " hot " when the thermometer in the sun shows a temperature superior to that of the body. It then approximates a Turkish bath.

A sun bath is termed " cold " when the thermometer shows a temperature inferior to that of the body.

When the favourable conditions described above are found

to work together—and this they practically always do as long as the sun shines—the patient experiences in his air bath those subjective sensations of well-being which are so conducive to the efficacy of the treatment and such a criterion of its suitability. Should the exposure to the sun be excessive—either in length or intensity—there may supervene a sensation of fatigue, want of appetite and even wakefulness. On the whole, pronounced general weakness, heart faults, aneurism, arterial sclerosis, febrile tuberculosis, organic diseases of the nervous system and tendency to hæmorrhage are counter-indications to violent insolation.

With reference to diet, it seems quite unnecessary to diverge from one's ordinary.

At Leysin, for instance, where tubercular patients are numbered by the thousand, Dr. Rollier does not fear any infection from the ordinary milk of the ordinary local cow. He does not favour any article of diet in particular. The physician's watchword is simply air and sunlight, and the specialty of the cure is to bring these to bear properly and in the required ratio upon the case of each patient.

The air and sun cure is the therapeutic employment of an agent of universal potency in the animal creation, endowed with power to exert a profound influence on the causation, growth and arrest of malignant processes. Particularly when the origin of the evil is respiratory, air and light are for it a general remedy, a therapeutic agent, which, embracing as it does oxygenation and oxidation, is both a universal food and natural constituent of the body. This therapeutic agent is at the same time a normal and fundamental determinant of cell life, *superlatively* available in the Alps.

To sum up, solar radiations are strongly bactericide factors. They may, under certain conditions, penetrate deep into the tissues and organs of the body. They dilate surface vessels and free from local congestion deeply situated organs, whose cells are profusely and differently oxygenated as an effect of sunlight. Solar radiations increase cell nutrition. They stimulate the nervous system. They accelerate the production of hæmoglobin and of blood corpuscles. Oxidation by means of the rays of the sun seems to be at the bottom of this multifarious process.

Those properties are as useful for the *prevention* as for the treatment of tuberculosis.

With reference to prevention, the importance of sunlight in the hygiene of housing should be recognised as absolutely paramount. Children particularly should, if possible, never live under town conditions. Air, light and sun should be allotted to them to an extent hitherto unrealised—or rather, unattainable under the artificial conditions of civilisation favoured by the bulk of a degenerate population.

Let us take, for instance, ninety-four children picked out at random in the poverty-stricken classes of the people, let the criterion of selection be well-defined tuberculosis in the first, second and third stages of virulence, let the air and sun cure at an altitude of 5,000 feet extend over 184 days on an average, let them be weighed on their departure; it will be found that the increase of weight per child exceeds 10 lbs., and that the following tables may be drawn up to illustrate the medical results of the cure :—

TABLE I.—TUBERCULAR CONDITION.

Condition on Entry.	Restored to Health.	Condition Improved.	Condition Unchanged.	Fatal Termination.	Totals.
In first stage of disease . .	60	4	—	—	64
In second stage of disease . .	10	15	1	—	26
In third stage of disease . .	—	2	1	1	4
Totals	70	21	2	1	94

TABLE II.—CONDITION OF FEVER.

On Admission.		On Leaving.		
	Patients.		Patients.	
38·5° C. and more.	2	38·5° C. and more	1	Case of death.
Under 38·5° C.	27	Under 38·5° C.	2	Condition unchanged.
Not feverish.	65	Free from fever	91	Restored to health, 70. Condition improved, 21.
Total . .	94			

TABLE III.—TUBERCULAR AND FEVER CONDITIONS.

Tubercular condition on Admission.	Fever on Admission.			Fever on Leaving.		
	38·5° C. and over.	Under 38·5° C.	Condition not feverish.	38·5° C. and over.	Under 38·5° C.	Condition not feverish.
	Patients.	Patients.	Patients.	Patients.	Patients.	Patients.
In first stage of disease . .	—	6	58	—	—	64
In second stage of disease .	—	19	7	—	—	26
In third stage of disease .	2	2	—	Case of death.	2	1
Totals .	2	27	65	1	2	91

People unacquainted with the exhilarating effect of sunlight and altitude combined would suppose that a visit to an Alpine sanatorium for children must be a saddening experience. If those people would put their supposition to the proof they would find that there is a pleasant surprise in store for them. In the open-air galleries, suffused with light and heat, the children lie or sit in their cots, amid their toys, kodaks, drawing materials, small writing desks, dolls, caged canaries, picture books, musical boxes and games of all sorts. A hum of happy voices and eyes gleaming with joy greet the astonished visitor. It is more like a holiday camp than an infirmary. There is nowhere any sign of pain or discomfort. A kind doctor, cheerful nurses and light, light, light pouring down from the vast open sky, and every corner flooded with air. Every countenance is lit up and beams upon a beautiful world of snowy peaks and hazy valleys spread out beyond the gallery railing, in front of the snuggest of homes.

The beds are pushed back into the bedrooms at night, but even then they are exposed to the night air, as the front side of every room has been knocked out. The rooms are windowless, though provided with curtains to keep out the snow. The little patients with open tuberculous sores seem quite indifferent to their plight. They are obviously either totally oblivious of every discomfort or totally free from any unpleasant sensation. Their cheeks are fat and chubby. The limbs

affected are alone shrivelled up, and painful to witness till the cure has had time to heal the sore places. Those whose bones have been eaten into by the disease undergo orthopædic treatment. Nourishment of the injured tissue sets in gradually, till they can get out of bed and be let out of the galleries in the open to make free use of the recovered activity of their limbs. With a cloth round their loins they roll about in the dry, sunny, powdery snow. Practically naked, with skins as black as old oak, they snowball one another, they skate, they pull the toboggans about, fly down the slopes on ski, a weird sight of swarthy gnomes scrambling about on the pure white banks that surround their Alpine abode.

I have seen parents bent with grief bringing in their arms from afar their disease-stricken child, with aching hearts clinging to a last forlorn hope. Joy overcame them when the mountain train in which they were huddled with others on the same errand pierced the bank of fog under which the last bit of their long journey had been completed. The lofty harbour stood now revealed, where they would commit the dear little one to the kindly sunlight on the friendly hillside. Send the children early. With adults the prospect is less promising. The disease is then hard to dislodge. Many grown-up people have ingrained habits of life which are a serious physiological impediment to their return to health by the abandonment of their own selves to the healing powers of nature. Could these but be again as little children, give up the frivolous wear and tear of self indulgence, wakeful pleasures, and the false excitements which they were shortsighted enough not to lay aside when their system began to be reduced to its pitiful condition!

To return to the purely objective aspects of the altitude cure, exposure of the nude body to the influence of the Alpine climate is becoming a more and more marked feature in the treatment. We could show to any audience illustrations which would leave them under an impression of blank astonishment. What my readers may see daily on the hot sands by the seaside in summer is what they may now see in the Swiss snows round the sanatoria: snow and air replace sand and water. It is the latest and most superlative application of the "back to nature" principle for the sound and sick alike. The young physicians who have struck out this new line know to what extent they are

throwing down the gauntlet to traditional medical opinion and to very superficial rules of decency. Yet they carry on steadfastly their policy of regeneration among patients whose condition marks them particularly for such bold departures from custom, in the comparative seclusion where exception cannot fairly be taken to the method.

Another question becomes more and more pressing now that ever larger crowds of visitors from the lowlands invade the Alpine altitudes all the year round, most thickly still in midsummer, though lately in midwinter too.

Hitherto, from the end of September to the beginning of July, altitudes were practically free from any rush of visitors. Hotel buildings were left to themselves, that is, to the cleansing influence of cold and sun, for eight months out of twelve. Being empty for so long, overcrowding for a short period could be viewed with some equanimity. But overcrowding, even for a short time, cannot be indulged in anywhere with impunity. Even on the most wind-swept English moorland the most temporary camp of Territorials has its sanitary officer. Military discipline ensures obedience to sanitary rule.

Three things have to be taken into consideration here, and to each much weight must be allowed. One is the material accommodation, another the indoor recreations in request among those who frequent mountain hotels. A third touches the conditions of health which hotel guests bring along with themselves from the towns in which most of them have their permanent homes.

1. The Hotel Accommodation.—This is not scanty. On the contrary, there are more Alpine hotels, and more room and bed accommodation is offered to every class of traveller than the available guests can fill. Unfortunately, this most honestly conducted branch of business is beset with two evils for which hotel keepers cannot be saddled with responsibility. The first is that people *will* flock to a limited number of well-known Alpine resorts which have the vogue, and patronise them in preference to others equally well situated and not less attractive. The second is that they insist on finding in those resorts huge edifices and town-like arrangements, restaurants, indoor

lounges, ballrooms. The result is obvious: within the hotel premises the guests surround themselves with the unsatisfactory health conditions from which they are supposed to be seeking temporary relief. People should take to heart that, wherever they go, they determine their own indoor climate, and whether their abode is—or is not—going to provide a proper feeding ground for the germs which they bring along with themselves. Physicians say with reason: Could not these hotels be better ventilated? The question is relevant, and the hotels should be ventilated. But the precept is difficult to obey without the concurrence of the hotel guests. If these object to the introduction through ventilators of a stream of air under freezing point—though its temperature may be immediately raised by passing over hot-air or hot-water radiators; if they will insist on lounging about the public rooms after midnight—leaving no time to throw the windows open and get up the heat again for the breakfast hour, what is then to be done?

Perhaps public opinion among hotel guests may become, through the medium of such lectures as these, sufficiently educated and enlightened to induce them to see for their own sake that the public rooms are cleared early enough for the night toilet of the hotel to go on unhindered. The indoor amusement committees might use their moral influence to much salutary effect.

Another very serious consequence of the crowding of guests in one huge structure—or in the packing of hotels close together in a bowl—is the accumulation of drainable matter upon one spot, or at different places within a very limited area. The soil becomes sodden in time; if there is a lake serving as outlet for the drainage, it tends to turn to a general cesspool; or the continuous frost of winter blocks the outlet of the pipes. The radical remedy would be a general sewer with branches to collect the objectionable matter and lead it straight away to a depth where winter frosts could not interfere with its flow, and the introduction of ovens for the destruction of garbage. But a still better policy would be to set one's face firmly against large hotels, or hotels built in close proximity to one another.

An improvement so far reaching must depend on the direction in which the public frequenting the Alps may henceforth use

their moral influence with the hotel trade. For the present the public still adheres to its own perverse conception of sanitation at altitudes. The only thing they seem capable of dreading is contamination by water, an almost always immaculate naturally filtered product of the mountain side, while their efforts should be addressed towards the erection of airy wooden chalets dotting the hillsides at intervals, with an airy earth closet at the back of each and a small oven for the burning of domestic garbage, connected with the central heater. These are the best dwelling-houses both for winter and summer.

As things are, the keeping up on the whole of a very high standard of health in the mammoth hotels which disfigure the Alps—hotels which demand all the complicated arrangements in use in town sanitation—is a *tour de force* for which the hotel trade and nature may claim immense and equal credit. It must be remembered that wherever there is a crowd there arises a subtly pestilent "crowd-poison," which it is extremely difficult to neutralise. The periodic sanitary inspection of hotels by a competent health officer should be arranged for.

2. Indoor Recreations.—These are practically all unsuited to the attainment of the avowed purpose of a sojourn in the Alps: health, exercise, relaxation of mind, enjoyment of scenery. They show, however much we may boast of our love of change, that we are, most of us, slaves to the dull demon whose name is sameness. The chief concern of hotel guests indoors seems to be to seek the company of their fellow creatures *en masse*. Now this is all very well out of doors; nothing more wholesome for the mind, and the crowd-poison cannot collect there, it is dispersed in the immensity of space.

But when a person who has just had influenza in his town home elbows sedulously, from the dinner hour to the end of a late dance, a partner whose own incipient influenza of like origin approaches fructification, what is the use of the Alpine climate that reigns royally and serenely outside the closed and heavily curtained windows? The world of fashion has its own code of health. Its devotees come out packed up in close sleeping berths, or mix breaths at close quarters with five or seven travelling companions tightly fitted into a railway compartment which already reeks with the outbreathings of multitudes.

They array themselves for dinner in garments that have not been previously aired in the unwalled air chambers of the Alps, and which have been worn night after night in the stifling promiscuity of social gatherings at home. A percentage of those people cannot escape developing the taints with which they have come laden: measles, scarlatina, throat disorders. The outbreaks that would have remained isolated had the victims not met, all take place in one and the same establishment in which they are now assembled. There is an accumulation of cases and rapid propagation ensues from one member of this adventitious community to another.

Indeed, they have come out for outdoor sports in the most sanitary air imaginable. They spend the daylight hours on the hillside right enough. But in the evening hours, instead of seeking repose in separate sleeping apartments with open windows, they indulge in the tainted pleasures of the ballroom, American bar, cardroom and restaurant.

3. Imported Conditions of Bad Health.—What people in apparent health are apt to bring up to altitudes are incipient inflammations, seated in the lungs, throat, brain cells, gouty tissues; or enfeebled organic functions of certain viscera: stomach, kidneys, etc. The stimulus of altitude will restore the activity of sluggish functions. But if indulgence ensues, no good is done. If self-control is practised, the functional insufficiency disappears by the effect of improved cell nutrition. In the case of the above symptoms, the inflammation of alien origin may be brought to a head by overheating (hotel life), or by refrigeration (after violent exercise), aggravating the imported inflammatory process before it has died out under the influence of the climate. Both cases mean fever.

Other causes of ill-being are found in the undisguised craving of many to use the benefit of stimulation by altitude in order to indulge in their favourite mode of dissipation with greater temporary immunity from consequences. We have seen that transference to an altitude induces some physiological strain. The strain is either a fillip or a tax. The system is whipped up. Consequently its stored-up energy is drawn upon. It will be detracted from, if not replenished. In other words, the stimulus of altitude must be employed in building up nervous

power. Instead of turning their attention to that all-important point, some people manage to bring about extreme nerve wastage. They undergo altitudinarian excitement. They wantonly debilitate their powers of resistance and, if they do not break down under the stress of outdoor sports, they return home with tired out organisms which fall at once an easy prey to the circumambient elements of bad health from which they had fled.

A last trivial remark. It is well known to all that after violent physical exercise, or as a consequence of prolonged immobility, the working temperature of the body goes down. Both slow and quick internal cooling down should be obviated. An additional bit of clothing, a warm teetotal drink, a little cold alcohol will do it. Clothes drenched with perspiration should be removed. At a pinch you may be content to shake yourself about in your garments to keep up the temperature of the skin by gentle friction ; keep your toes moving in your boots, beat your sides with your extended arms crossed over your chest.

Townspeople seeking the Alps should lead the outdoor life which induces sound sleep, they should go to bed early, they should rise betimes, give up alcoholic drinks, the smoking room, the billiard table. They should stroll out of doors after dinner, lounge in open verandas when the night is starry, quench their thirst with cooling drinks (such as lemon juice mixed with very light *hot* tea), wear warm dry clothing when not taking violent exercise, face all weathers. Those rules seem stringent and faddy. But those whom we request to comply with them should realise that in almost every case they have come out to the Alps for a short time only, and in quest of new sensations for the full enjoyment of which they need be in "tip-top" condition.

By compliance with such obvious principles the conditions of bad health which do spring up here and there from hotel life may be checked, so that the guests may return home with a braced-up system and unmixed grateful memories of their Alpine holiday. There is no happiness of the mind without discipline of the body. In the first cup dwells health, in the second there is elation, the third brings madness, and the fourth ends in death, says a very wise motto that was not coined yesterday.

It seems relevant to add to this final chapter a few short notes on the medical treatment of the prisoners of war interned in Switzerland during the world-wide conflagration, 1914—1918. This mention need only include patients of the tubercular class, whatever the nationality, and irrespective of the kind or stage of the tubercular taint. Such patients were collected in the linked stations of Aigle-Leysin, Valais-Bex, Weissenburg-Chateau d'Oex, Lenzerheide-Davos. The subjoined table shows that out of 6,415 cases, 2,499, viz. 39 per cent., were reported cured in 1917.

	Entente Powers.				Central Powers.			General Total.
	French.	Belgians.	English.	Total.	Germans.	Austro-Hungarians.	Total.	
Cases	3326	321	448	4095	2190	130	2320	6415
Cures	1340	101	86	1527	925	47	972	2499
	Percentage of Cures ..			37·3%			42%	39%

The treatment was essentially by air and sun, with any adjuncts required. Heliotherapy was pre-eminently successful in the treatment of secretory bone fistulas of one or two years' standing, which were cured in a comparatively short period.

It is not our business to call attention to the proportion of cures in each nationality. Most English patients came from the "old army."

ALPHABETICAL TABLES.

PART I

INDEX

In Part I. there is a constant reference to *cold*, as determined by *altitude* or *latitude*, to health or disease connected therewith, and to apposite principles of *hygiene*.

PART II

INDEX

The general reference underlying this alphabetical table for Part II. is to the *air* at *altitudes*, its component *gases*, and its influence upon well-being, particularly upon the composition of the *blood* and upon *longevity*.

PART III

INDEX

The general reference in this Part is to *solar light* and *solar heat* as curative elements in the climate of *altitude*.

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